FIG.1

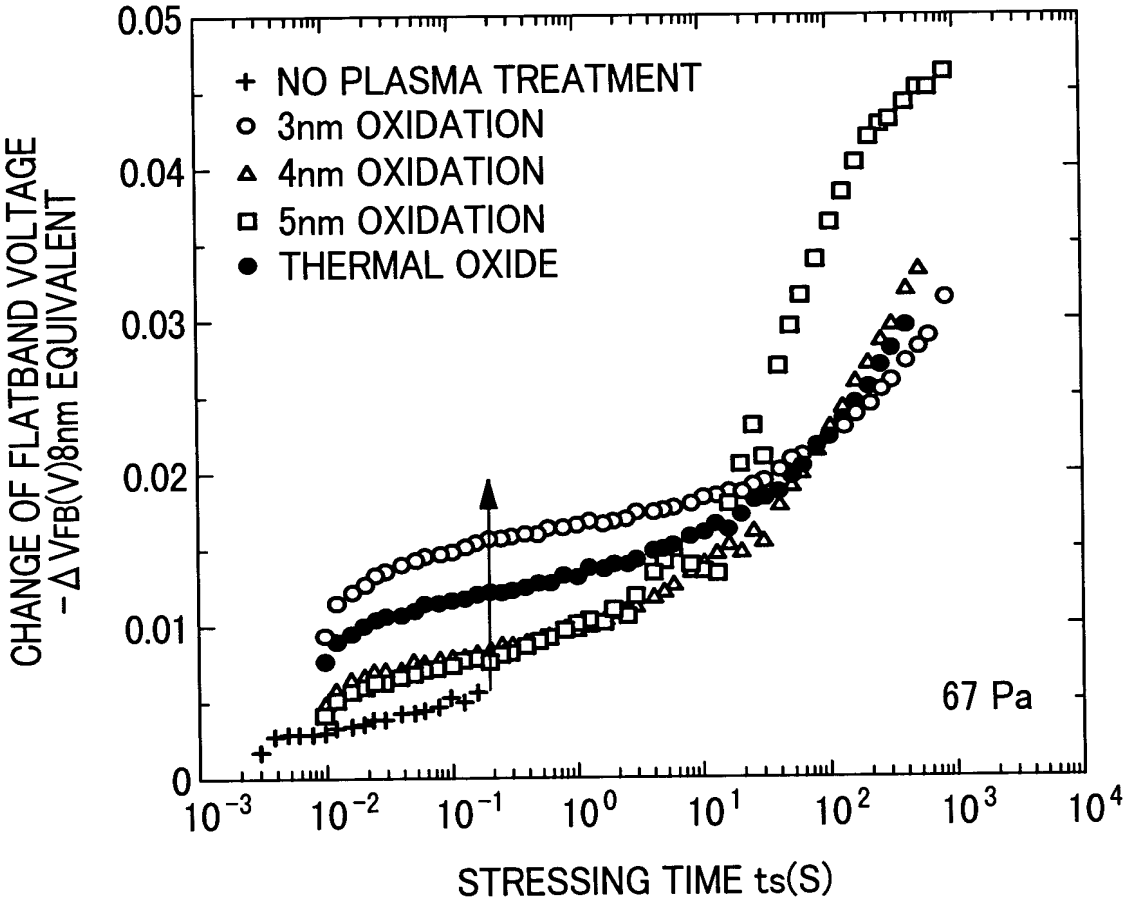
0.05
0.04
0.03
0.02
0.01
0
+ NO PLASMA TREATMENT
o 3nm OXIDATION
Δ 4nm OXIDATION
□ 5nm OXIDATION
● THERMAL OXIDE
67 Pa
CHANGE OF FLATBAND VOLTAGE
-ΔVFB(V)8nm EQUIVALENT
10-3
10-2
10-1
100
101
102
103
104
STRESSING TIME ts(S)

FIG.2

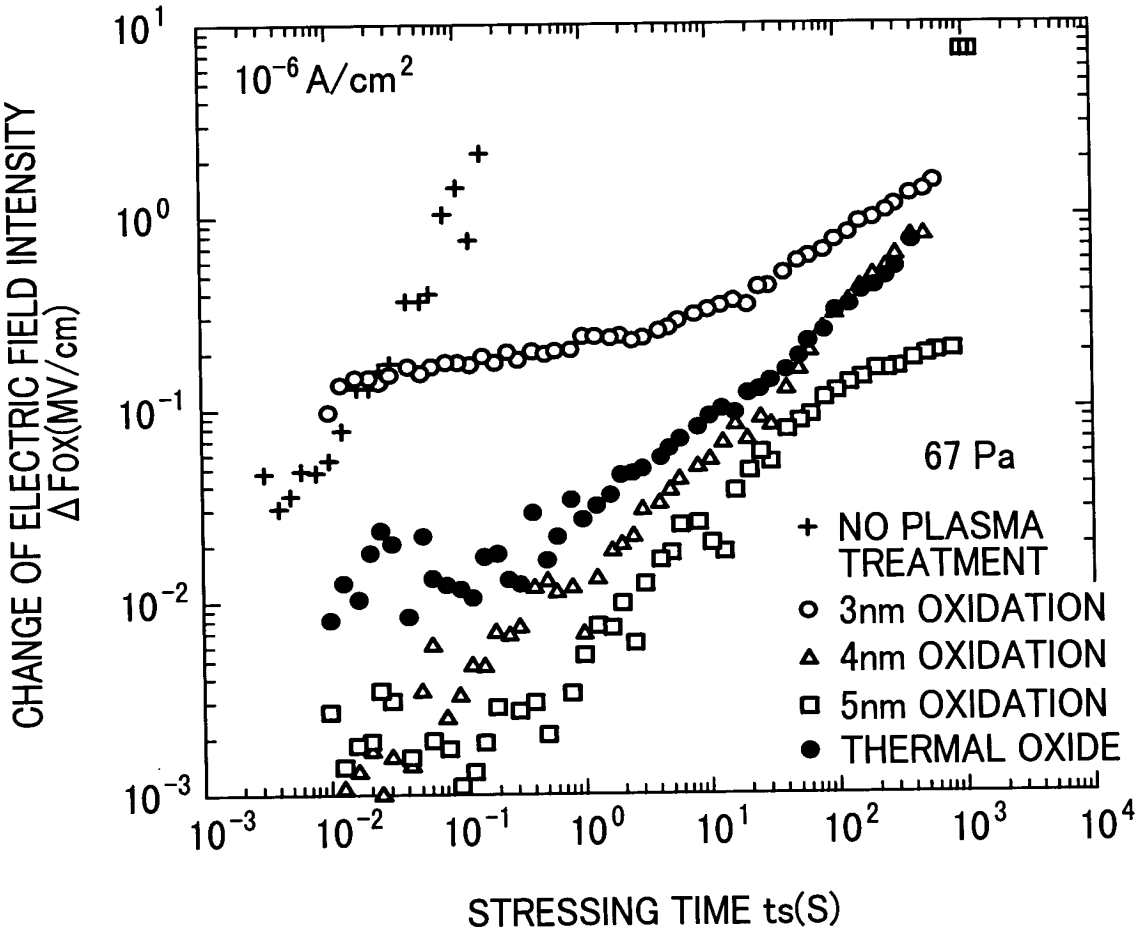
10^{-6} A/cm^2
67 Pa
+ NO PLASMA TREATMENT
○ 3nm OXIDATION
△ 4nm OXIDATION
□ 5nm OXIDATION
● THERMAL OXIDE
CHANGE OF ELECTRIC FIELD INTENSITY ΔFOX(MV/cm)
STRESSING TIME ts(S)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}

FIG.3

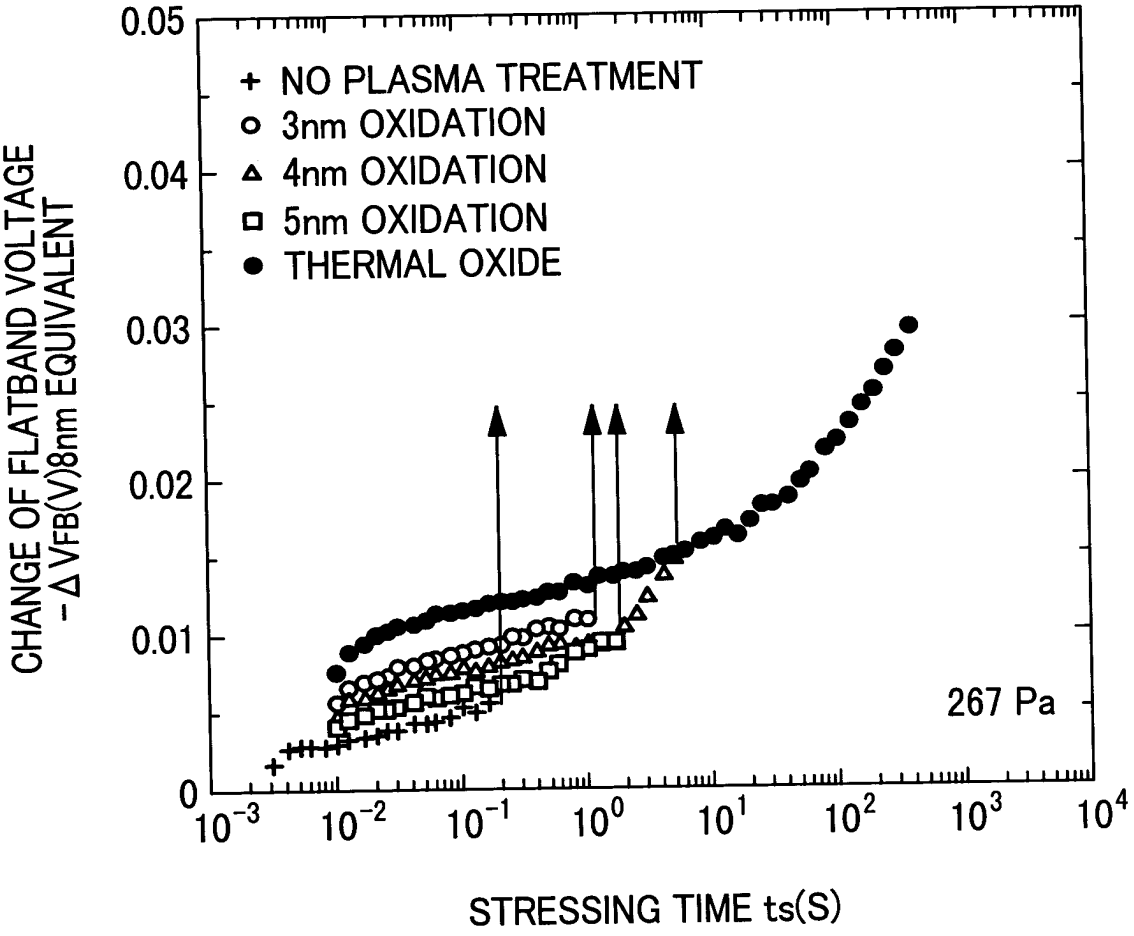
0.05
0.04
0.03
0.02
0.01
0
+ NO PLASMA TREATMENT
o 3nm OXIDATION
△ 4nm OXIDATION
□ 5nm OXIDATION
● THERMAL OXIDE
267 Pa
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
CHANGE OF FLATBAND VOLTAGE
$-\Delta V_{FB}$(V)8nm EQUIVALENT
STRESSING TIME ts(S)

FIG.4

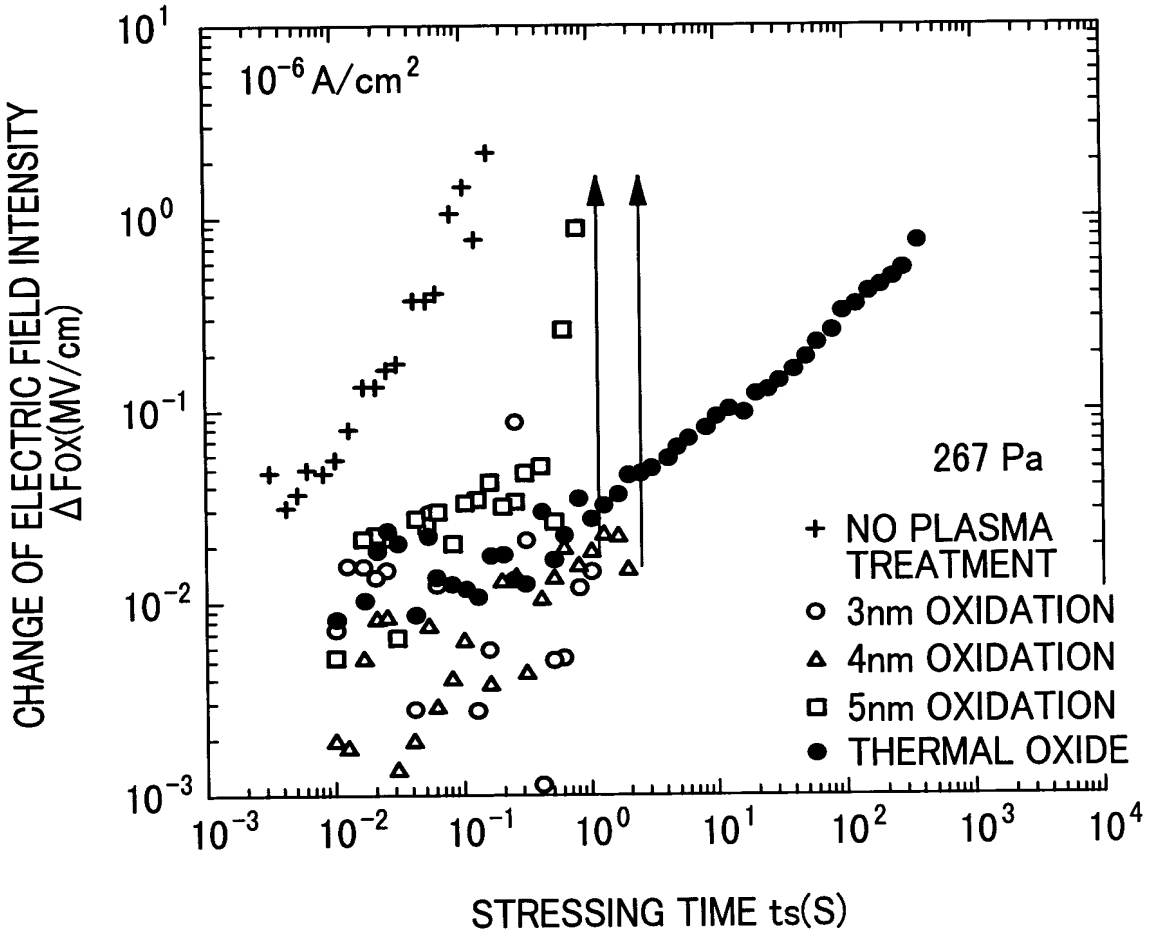
10^{-6} A/cm^2
267 Pa
+ NO PLASMA TREATMENT
○ 3nm OXIDATION
△ 4nm OXIDATION
□ 5nm OXIDATION
● THERMAL OXIDE
CHANGE OF ELECTRIC FIELD INTENSITY ΔFOX(MV/cm)
STRESSING TIME ts(S)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}

FIG.5

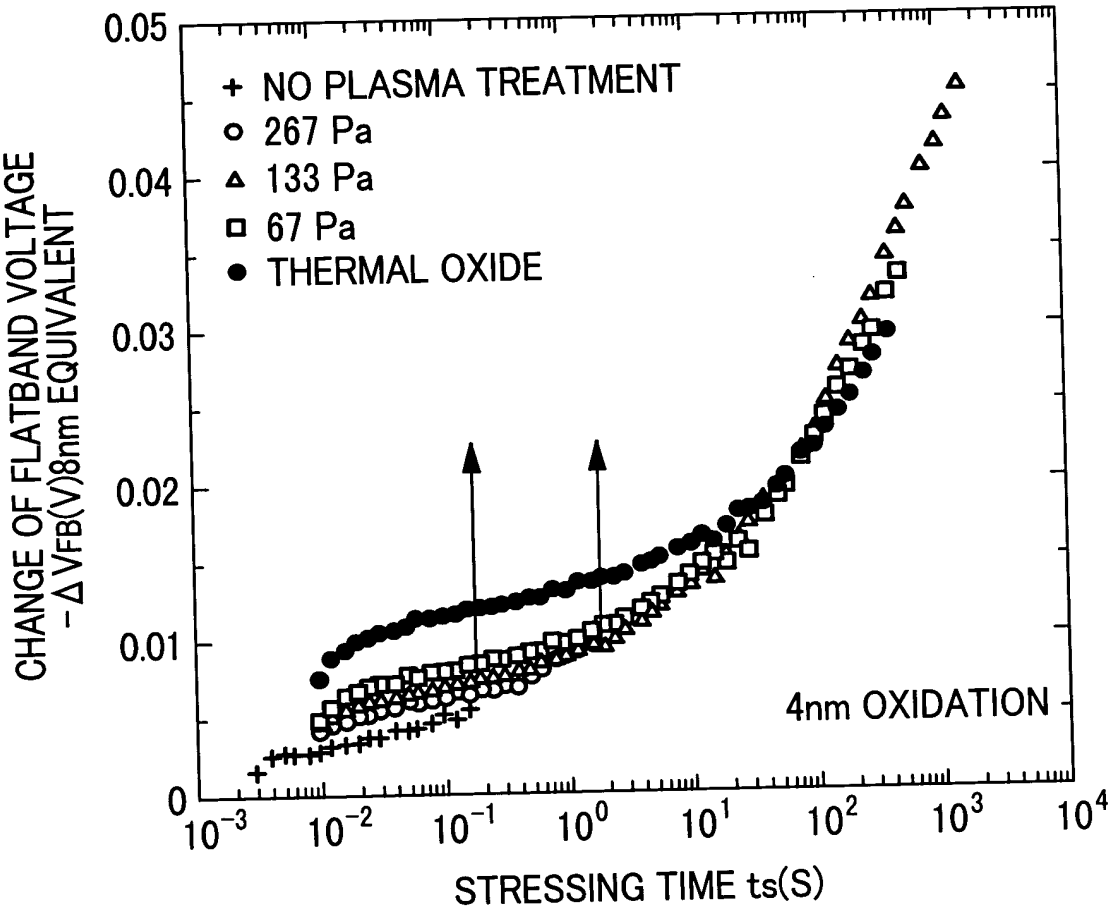
0.05
0.04
0.03
0.02
0.01
0
+ NO PLASMA TREATMENT
○ 267 Pa
△ 133 Pa
□ 67 Pa
● THERMAL OXIDE
4nm OXIDATION
CHANGE OF FLATBAND VOLTAGE
-ΔVFB(V)8nm EQUIVALENT
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
STRESSING TIME ts(S)

FIG.6

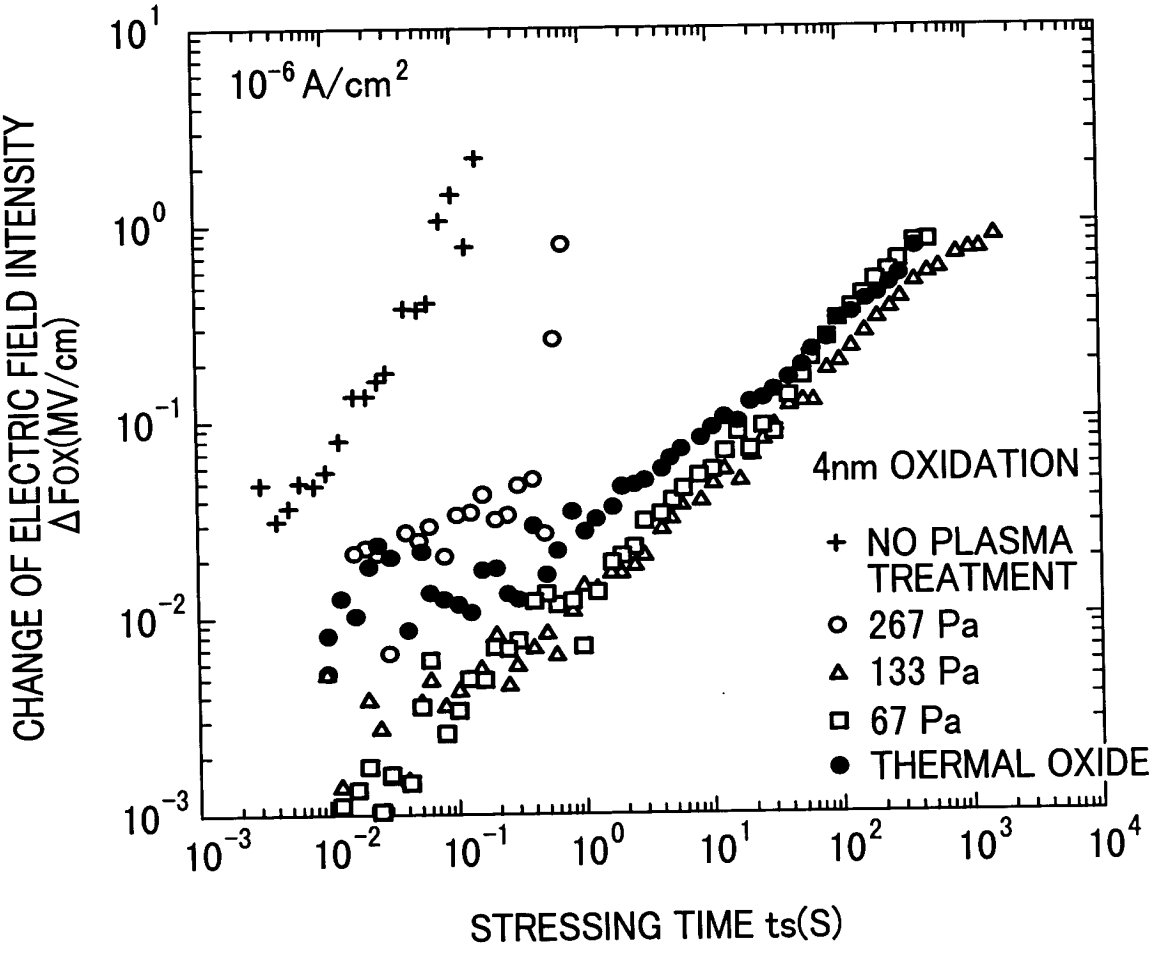
10^{-6} A/cm^2
4nm OXIDATION
+ NO PLASMA TREATMENT
○ 267 Pa
△ 133 Pa
□ 67 Pa
● THERMAL OXIDE
CHANGE OF ELECTRIC FIELD INTENSITY ΔFOX(MV/cm)
STRESSING TIME ts(S)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}

FIG.7

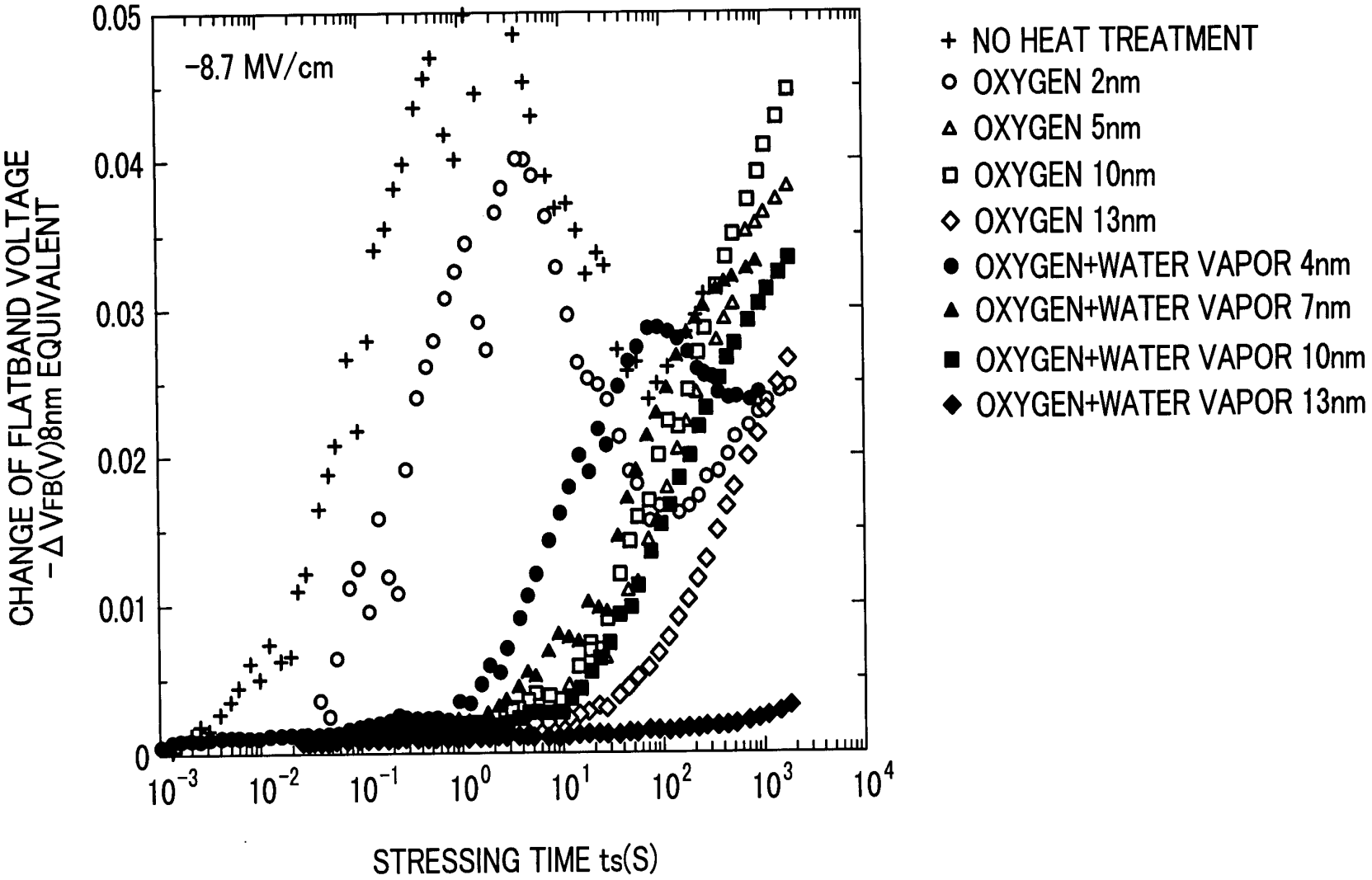
-8.7 MV/cm
CHANGE OF FLATBAND VOLTAGE
- ΔVFB(V)8nm EQUIVALENT
0.05
0.04
0.03
0.02
0.01
0
10-3
10-2
10-1
100
101
102
103
104
STRESSING TIME ts(S)
NO HEAT TREATMENT
OXYGEN 2nm
OXYGEN 5nm
OXYGEN 10nm
OXYGEN 13nm
OXYGEN+WATER VAPOR 4nm
OXYGEN+WATER VAPOR 7nm
OXYGEN+WATER VAPOR 10nm
OXYGEN+WATER VAPOR 13nm

FIG.8

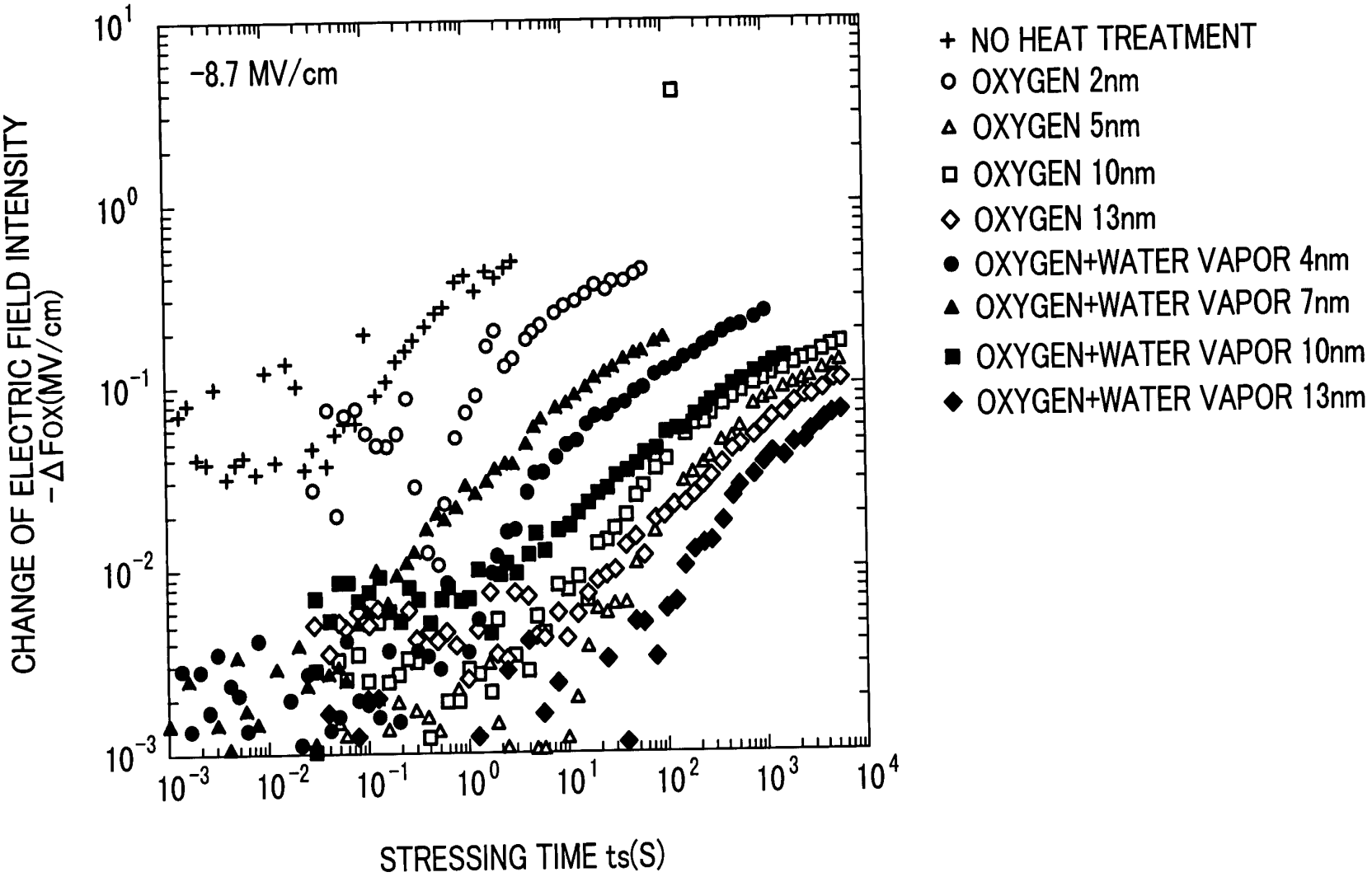
-8.7 MV/cm
CHANGE OF ELECTRIC FIELD INTENSITY
-ΔFOX(MV/cm)
STRESSING TIME ts(S)
NO HEAT TREATMENT
OXYGEN 2nm
OXYGEN 5nm
OXYGEN 10nm
OXYGEN 13nm
OXYGEN+WATER VAPOR 4nm
OXYGEN+WATER VAPOR 7nm
OXYGEN+WATER VAPOR 10nm
OXYGEN+WATER VAPOR 13nm

FIG.9

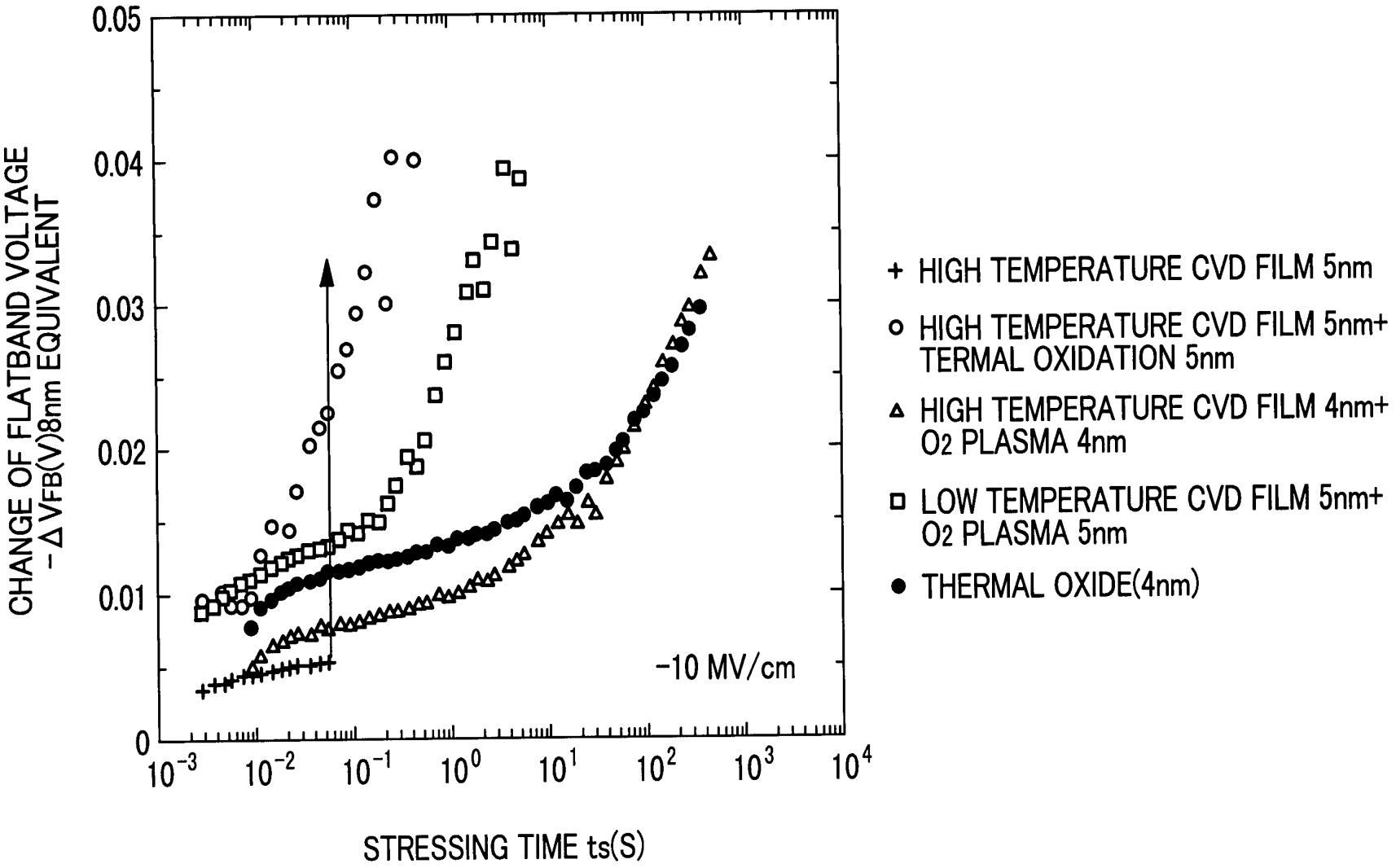
CHANGE OF FLATBAND VOLTAGE
- Δ VFB(V)8nm EQUIVALENT
0.05
0.04
0.03
0.02
0.01
0
10-3
10-2
10-1
100
101
102
103
104
-10 MV/cm
STRESSING TIME ts(S)
+ HIGH TEMPERATURE CVD FILM 5nm
o HIGH TEMPERATURE CVD FILM 5nm+ TERMAL OXIDATION 5nm
Δ HIGH TEMPERATURE CVD FILM 4nm+ O2 PLASMA 4nm
□ LOW TEMPERATURE CVD FILM 5nm+ O2 PLASMA 5nm
● THERMAL OXIDE(4nm)

FIG.10

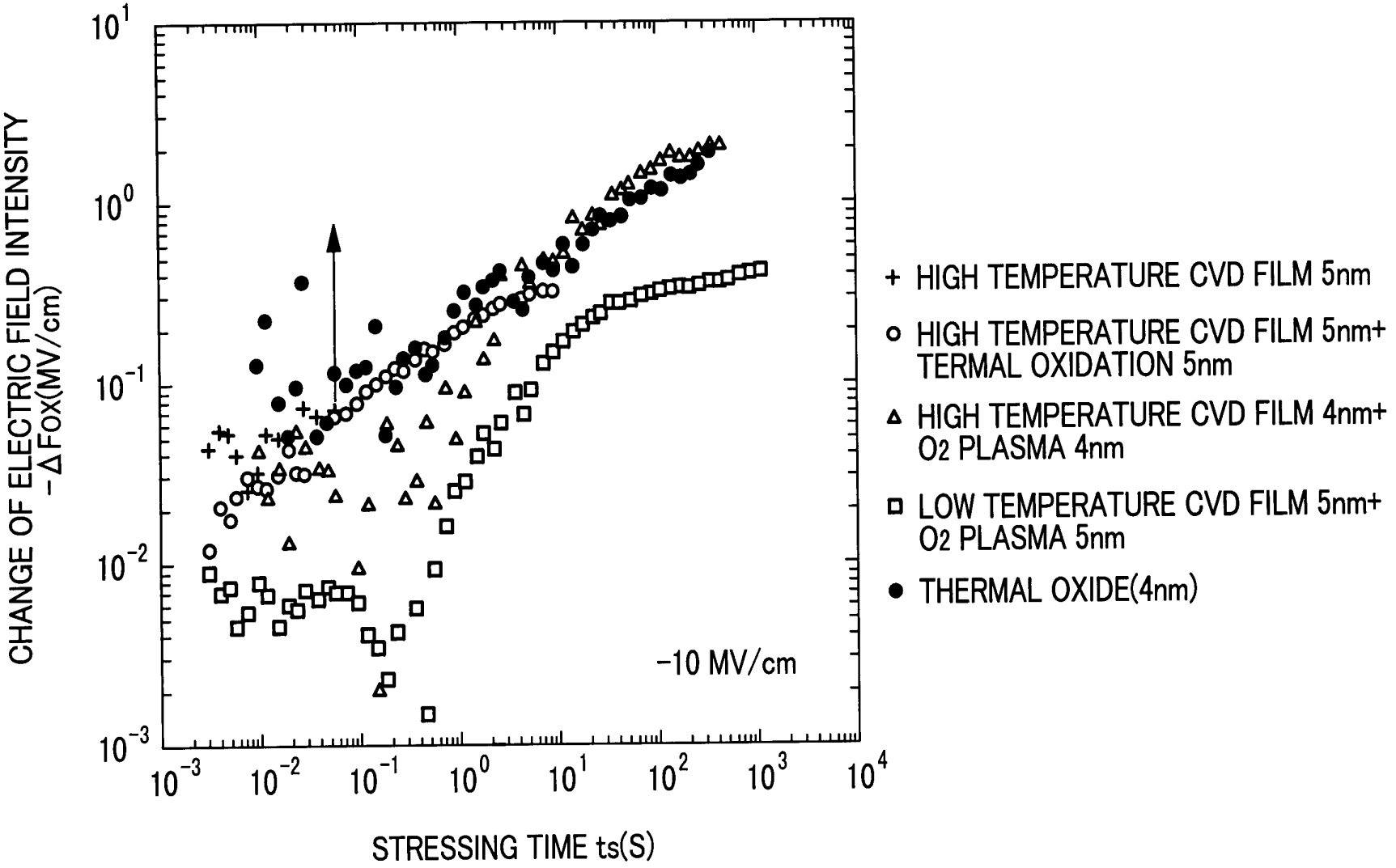
CHANGE OF ELECTRIC FIELD INTENSITY
-ΔFox(MV/cm)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}
STRESSING TIME ts(S)
-10 MV/cm
+ HIGH TEMPERATURE CVD FILM 5nm
o HIGH TEMPERATURE CVD FILM 5nm+ TERMAL OXIDATION 5nm
△ HIGH TEMPERATURE CVD FILM 4nm+ O2 PLASMA 4nm
□ LOW TEMPERATURE CVD FILM 5nm+ O2 PLASMA 5nm
● THERMAL OXIDE(4nm)

FIG.11

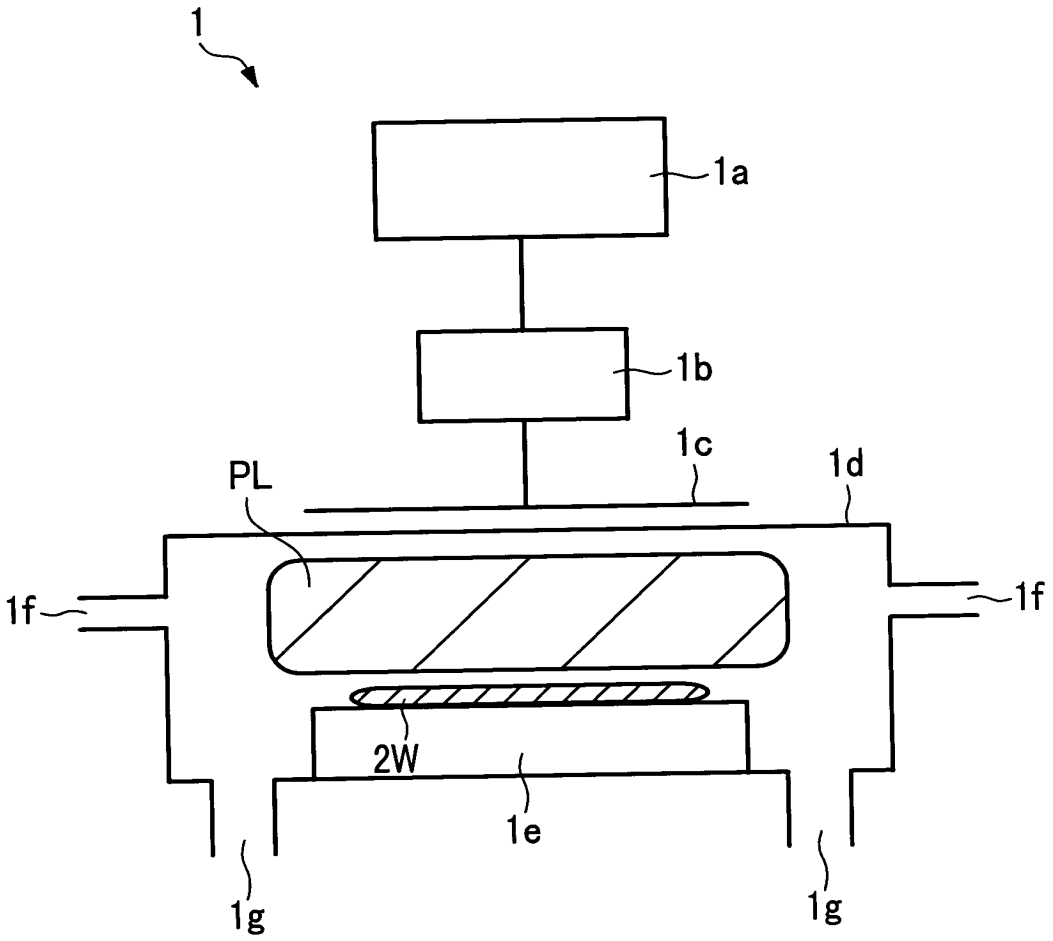

FIG.12

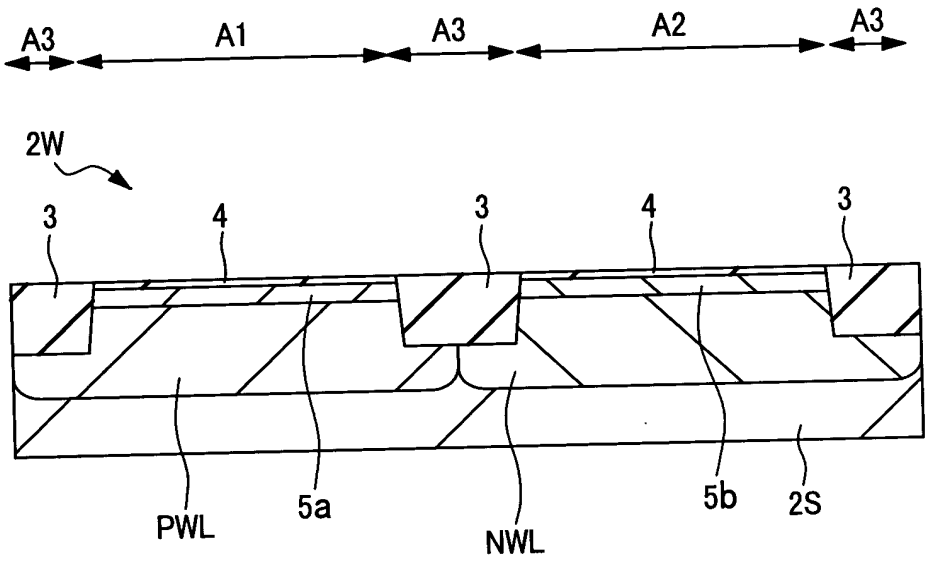
A3
A1
A3
A2
A3
2W
3
4
3
4
3
PWL
5a
NWL
5b
2S

FIG.13

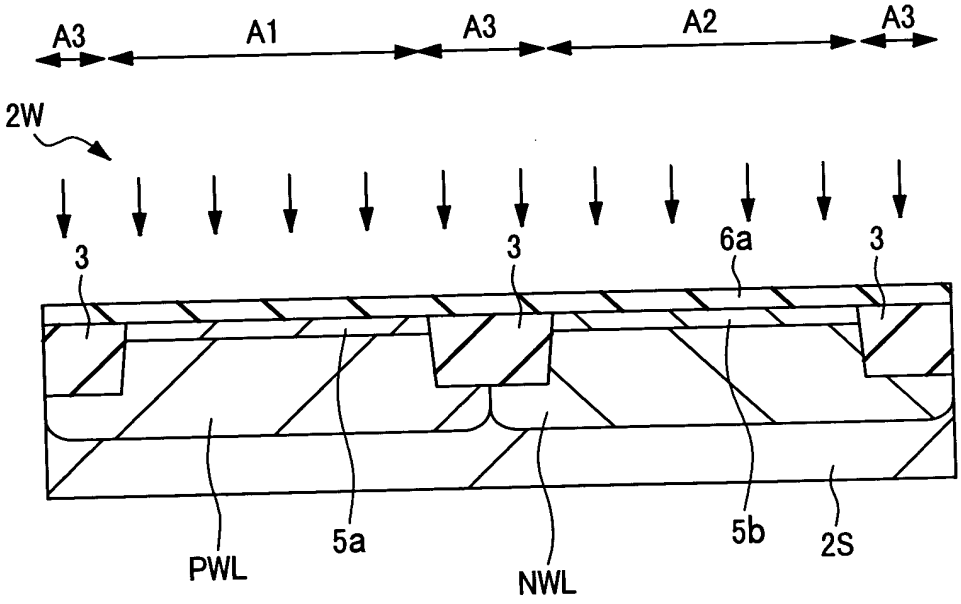
A3
A1
A3
A2
A3
2W
3
3
6a
3
PWL
5a
NWL
5b
2S

FIG.14

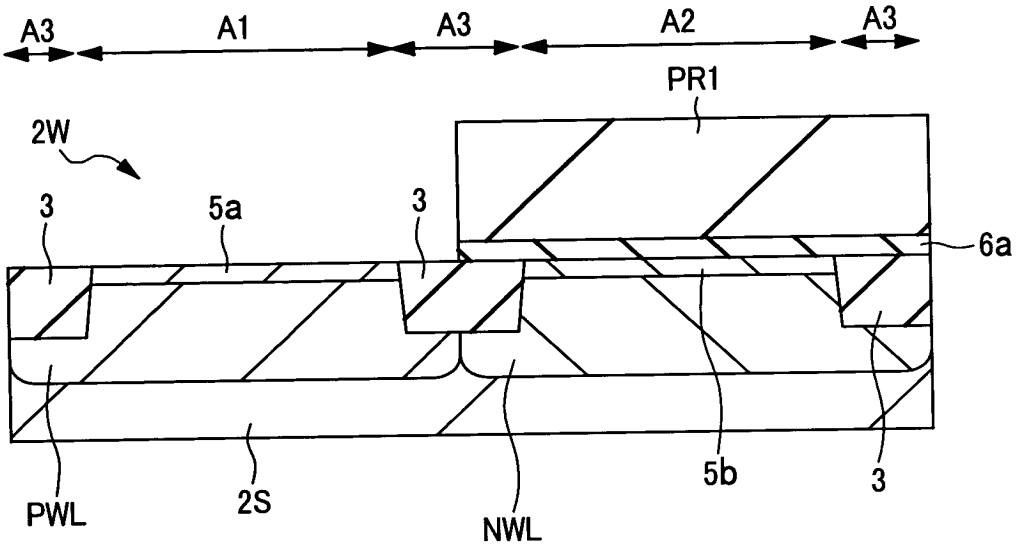
A3
A1
A3
A2
A3
PR1
2W
3
5a
3
6a
PWL
2S
NWL
5b
3

FIG.15

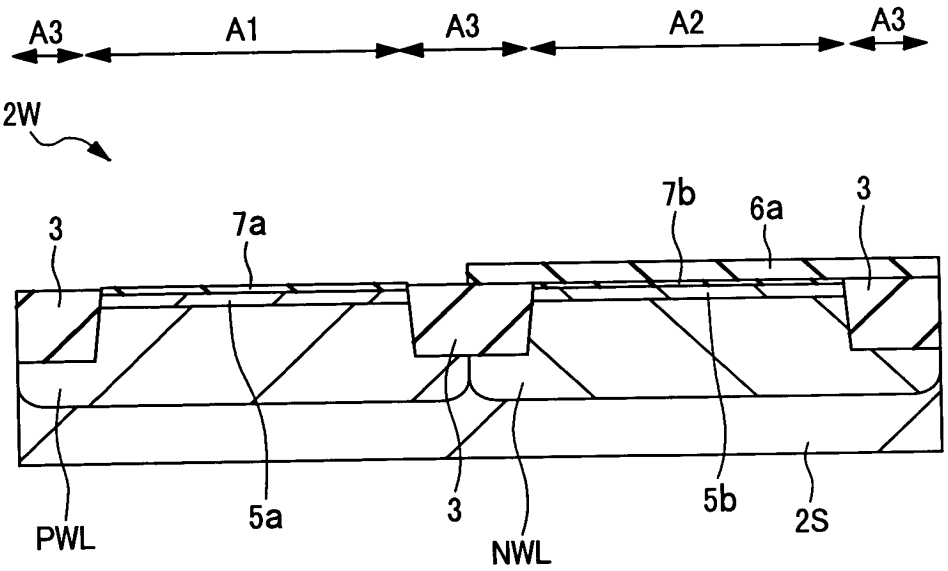
A3
A1
A3
A2
A3
2W
3
7a
7b
6a
3
PWL
5a
3
NWL
5b
2S

FIG.16

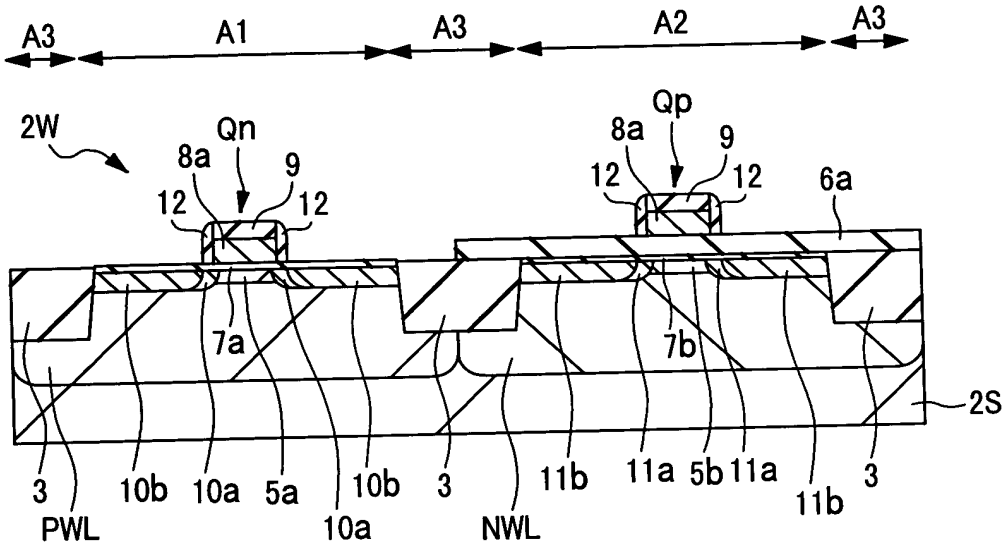
A3
A1
A3
A2
A3
2W
Qn
8a
9
12
12
Qp
8a
9
12
12
6a
7a
7b
2S
3
PWL
10b
10a
5a
10a
10b
3
NWL
11b
11a
5b
11a
11b
3

FIG.17

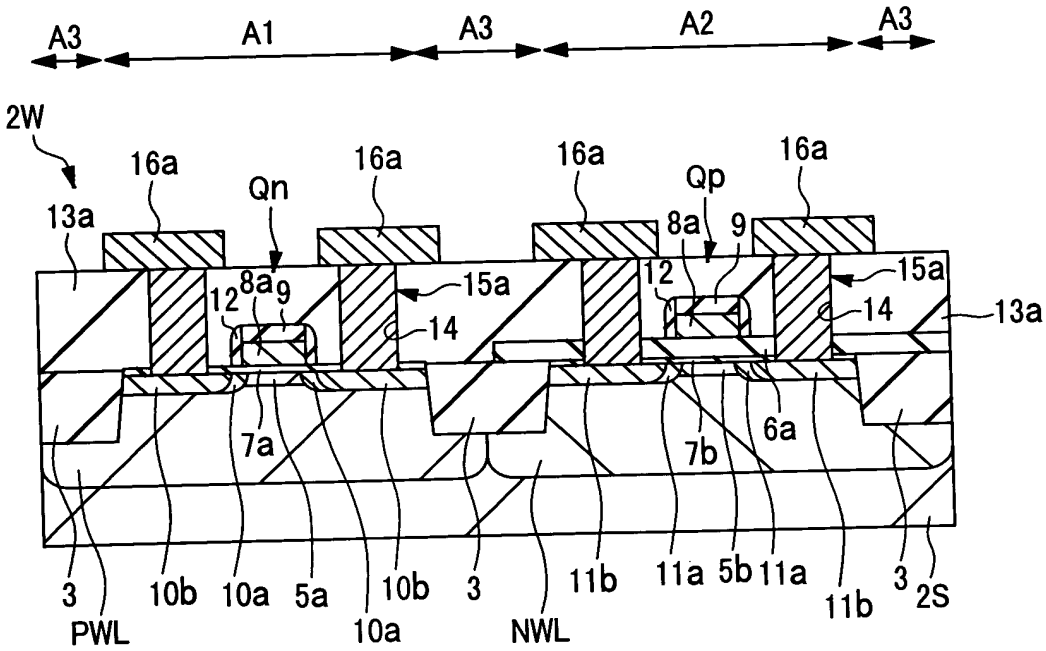
A3
A1
A3
A2
A3
2W
16a
16a
16a
16a
13a
Qn
Qp
8a
9
8a
9
12
12
15a
15a
14
14
13a
7a
7b
6a
3
PWL
10b
10a
5a
10a
10b
3
NWL
11b
11a
5b
11a
11b
3
2S

FIG.18

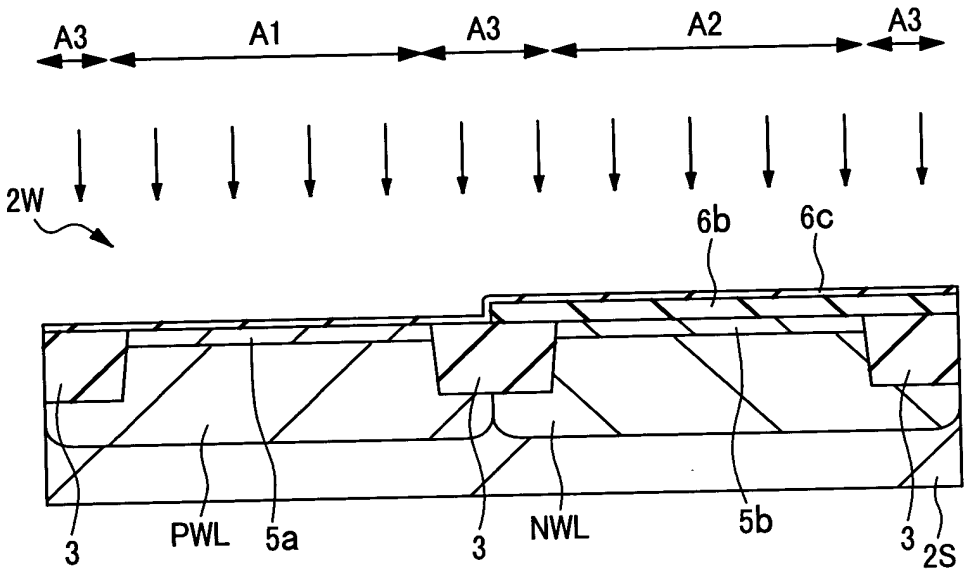
A3
A1
A3
A2
A3
2W
6b
6c
3
PWL
5a
3
NWL
5b
3
2S

FIG.19

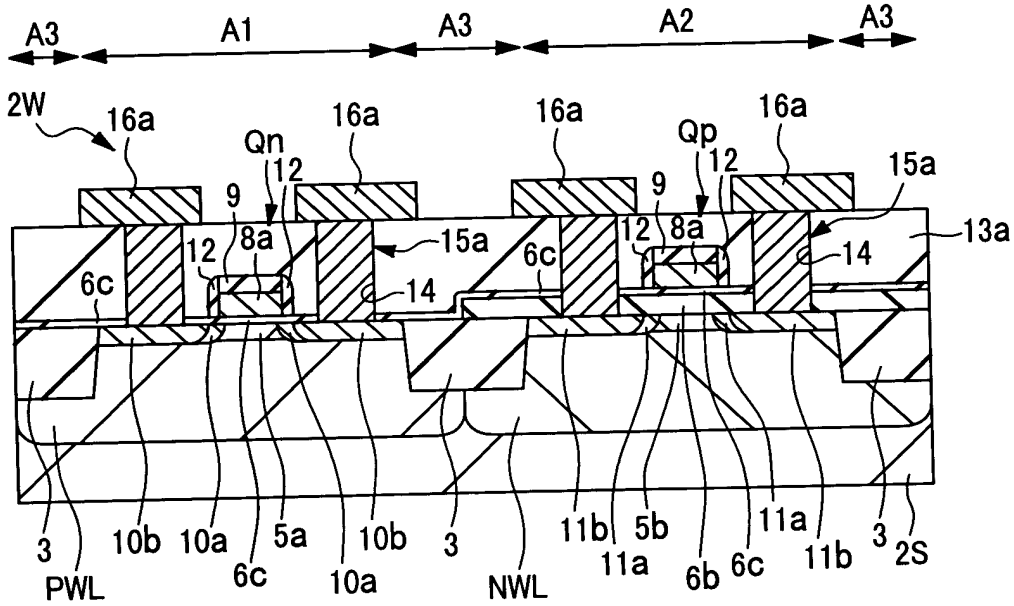
A3
A1
A3
A2
A3
2W
16a
Qn
16a
16a
Qp
16a
12
9
12
9
15a
13a
12
8a
15a
6c
12
8a
14
6c
6c
14
3
PWL
10b
10a
6c
5a
10a
10b
3
NWL
11b
11a
5b
6b
6c
11a
11b
3
2S

FIG.20

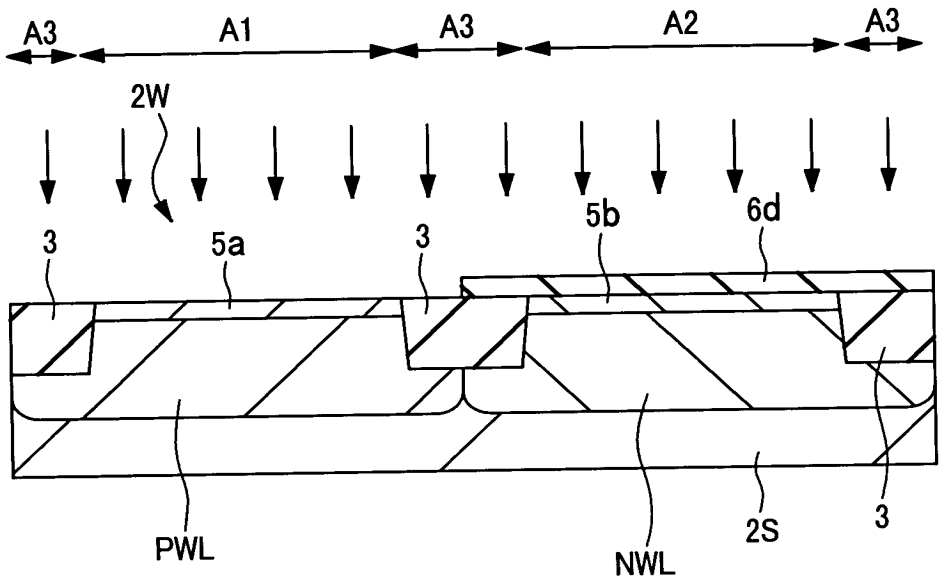
A3
A1
A3
A2
A3
2W
3
5a
3
5b
6d
PWL
NWL
2S
3

FIG.21

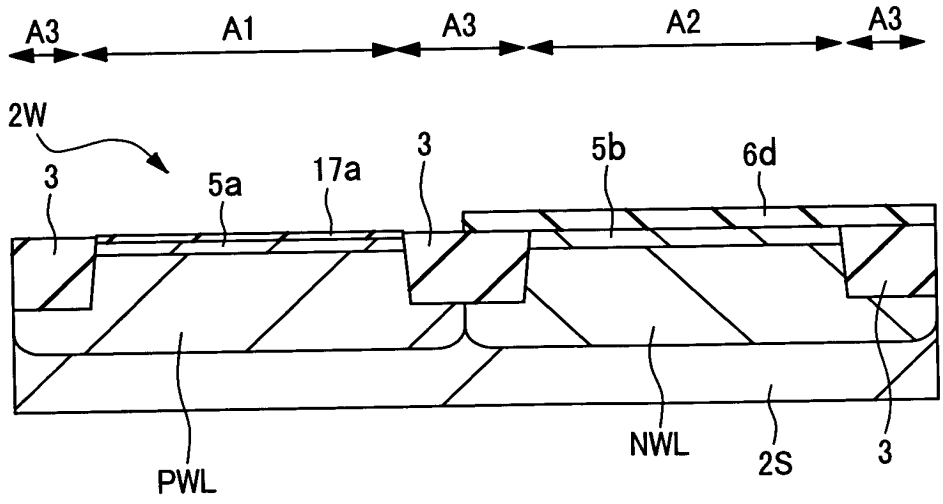
A3
A1
A3
A2
A3
2W
3
5a
17a
3
5b
6d
PWL
NWL
2S
3

FIG.22

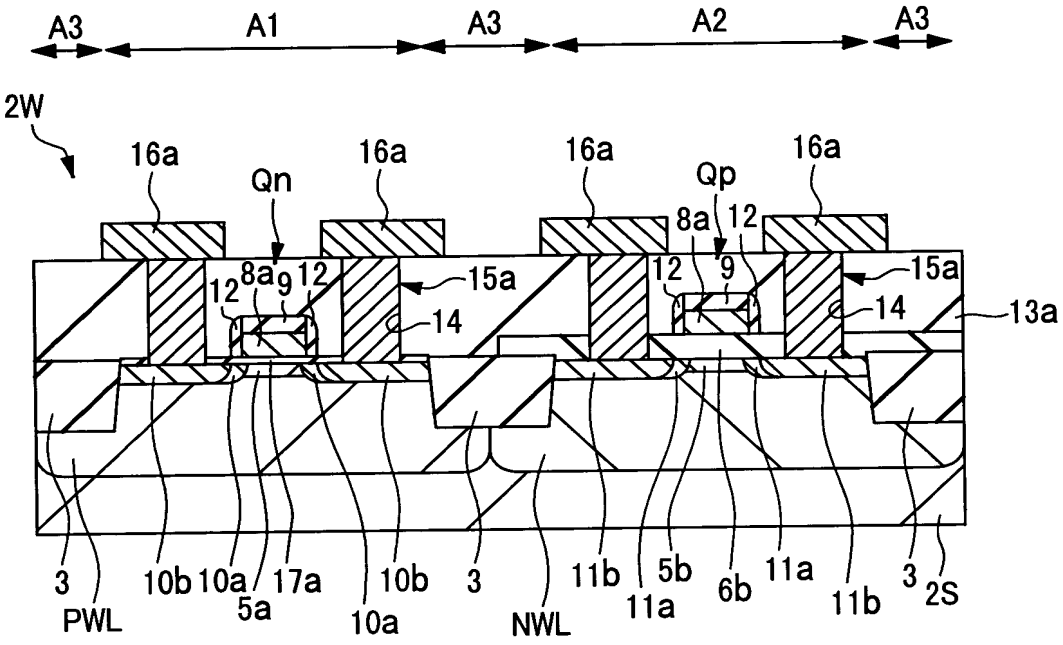
A3
A1
A3
A2
A3
2W
16a
16a
16a
16a
Qn
Qp
8a
12
12
8a
9
12
12
9
15a
15a
14
14
13a
3
PWL
10b
10a
5a
17a
10a
10b
3
NWL
11b
11a
5b
6b
11a
11b
3
2S

FIG.23

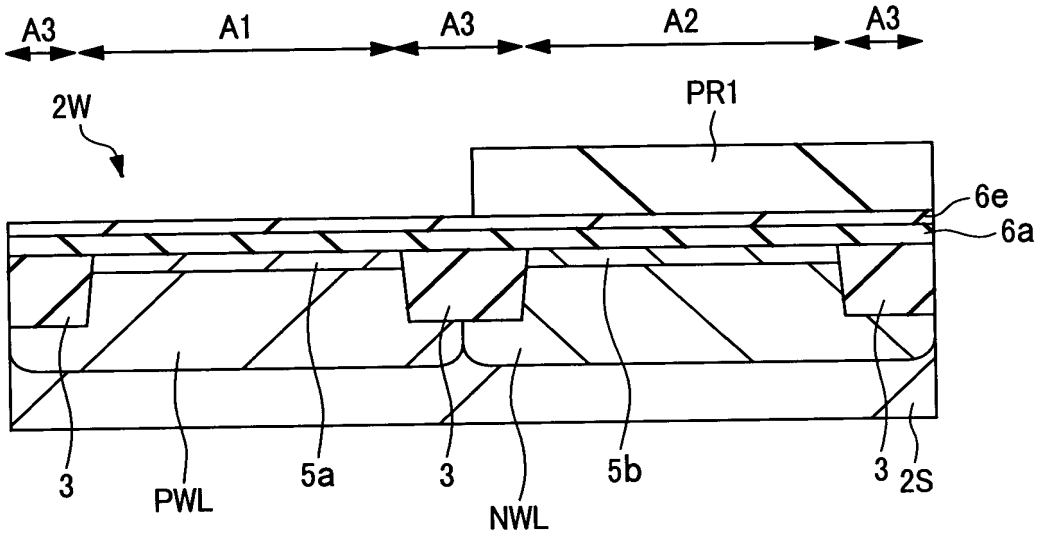
A3
A1
A3
A2
A3
2W
PR1
6e
6a
3
PWL
5a
3
NWL
5b
3
2S

FIG.24

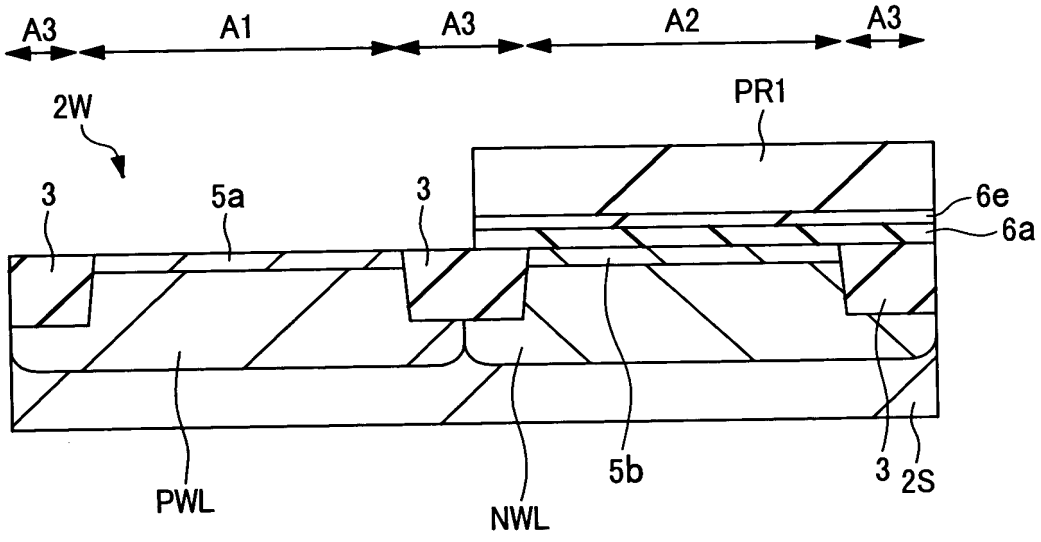
A3
A1
A3
A2
A3
2W
PR1
3
5a
3
6e
6a
PWL
NWL
5b
3
2S

FIG.25

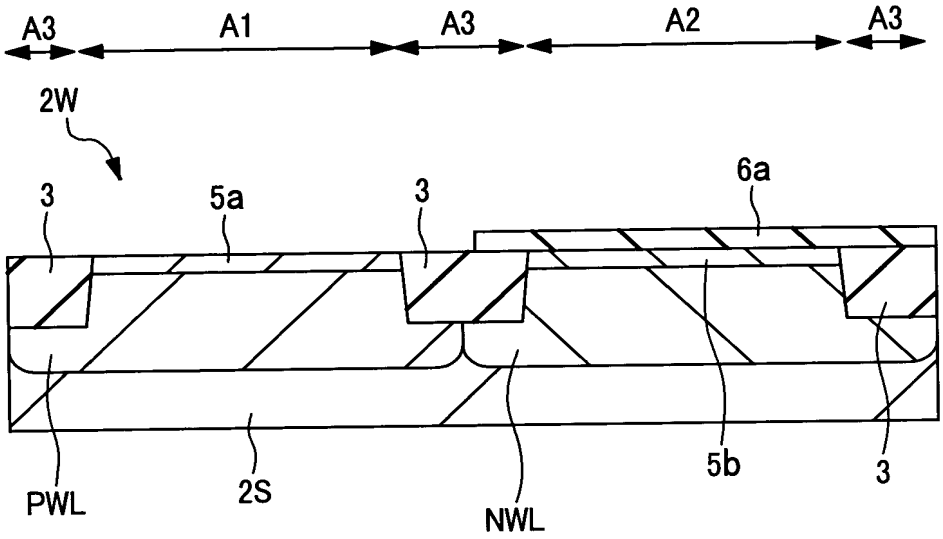
A3
A1
A3
A2
A3
2W
3
5a
3
6a
PWL
2S
NWL
5b
3

FIG.26

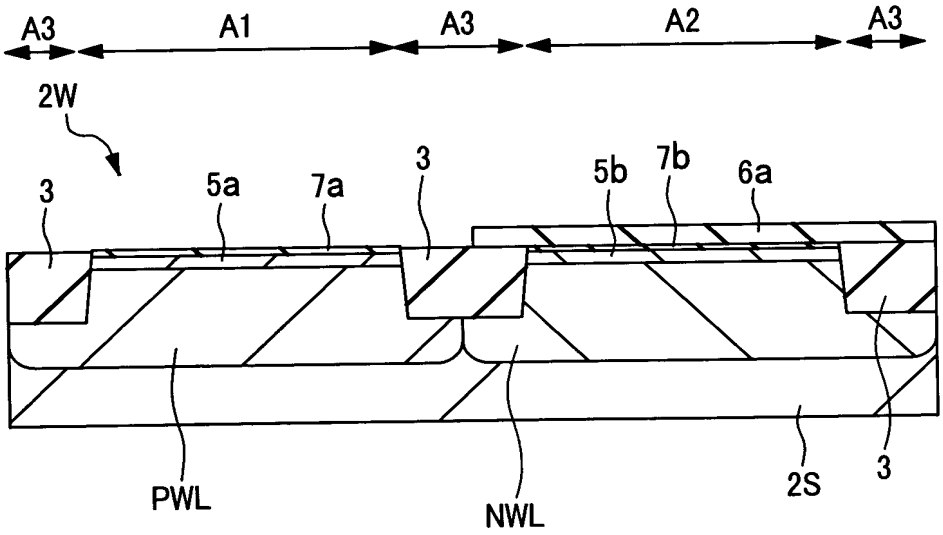
A3
A1
A3
A2
A3
2W
3
5a
7a
3
5b
7b
6a
PWL
NWL
2S
3

FIG.27

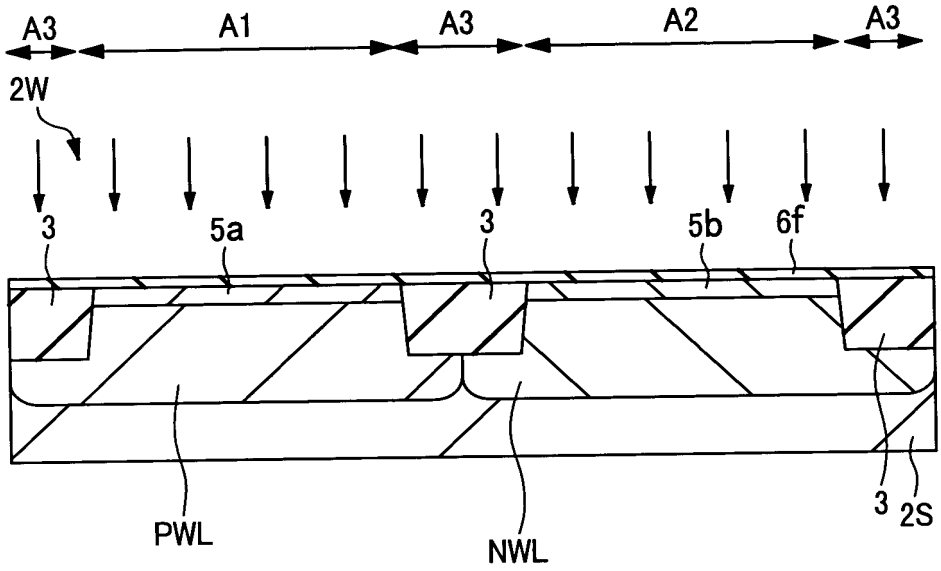
A3
A1
A3
A2
A3
2W
3
5a
3
5b
6f
PWL
NWL
3
2S

FIG.28

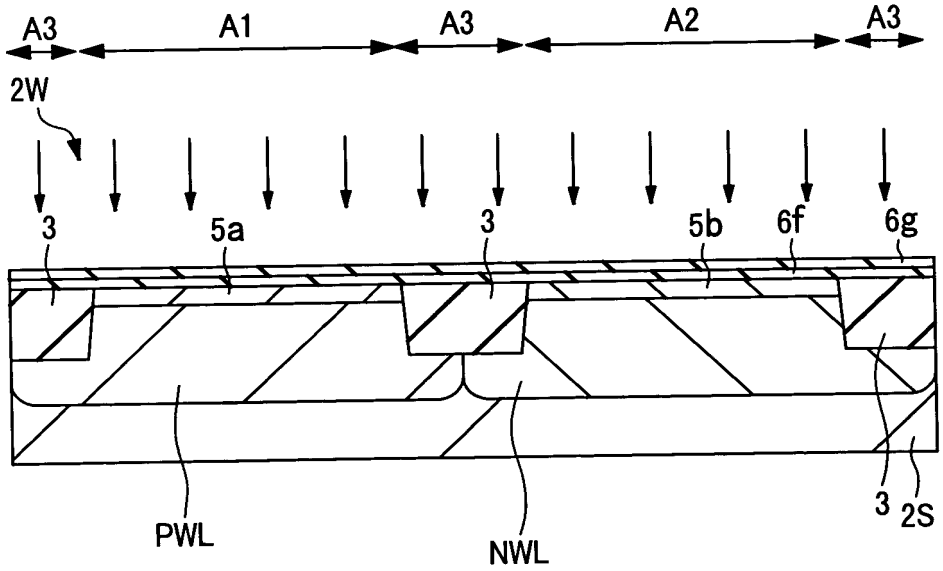
A3
A1
A3
A2
A3
2W
3
5a
3
5b
6f
6g
PWL
NWL
3
2S

FIG.29

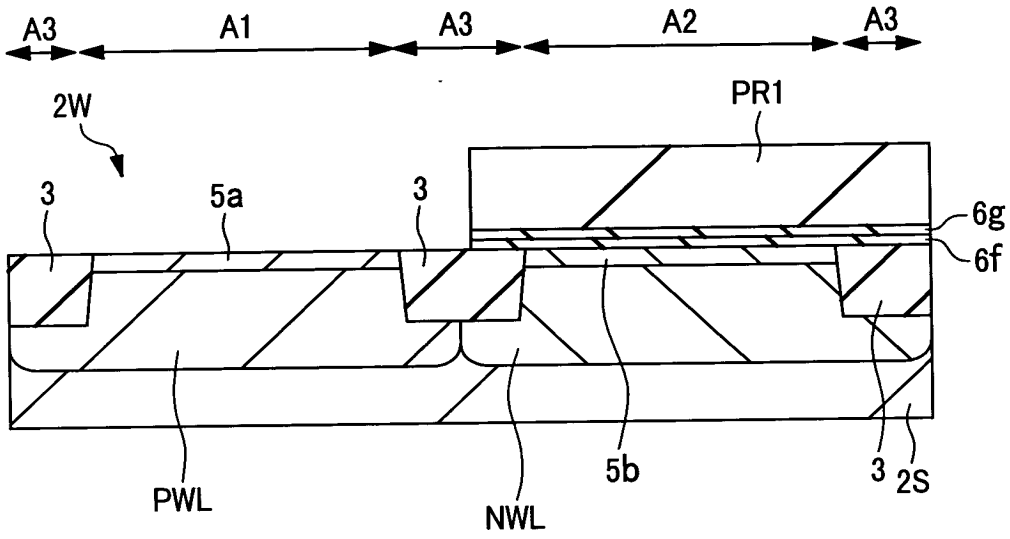
A3
A1
A3
A2
A3
2W
PR1
3
5a
3
6g
6f
PWL
NWL
5b
3
2S

FIG.30

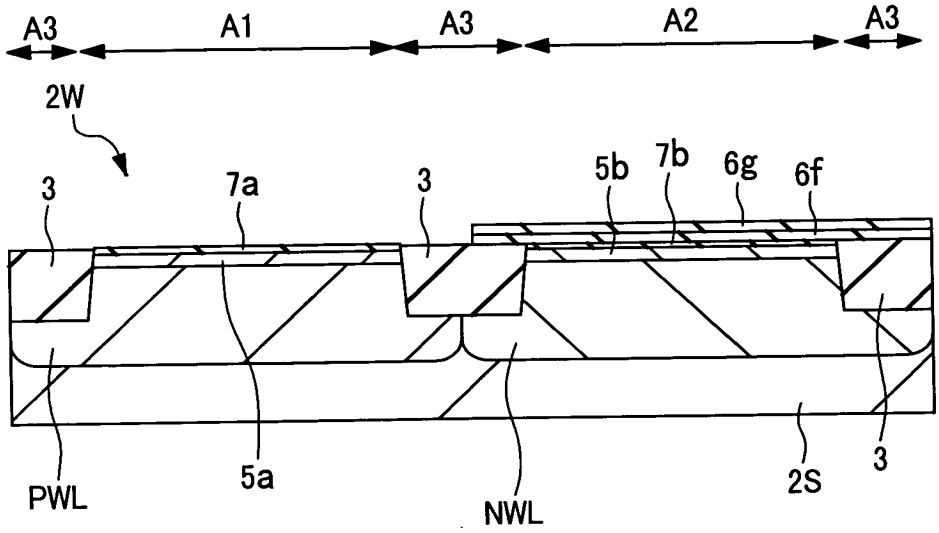
A3
A1
A3
A2
A3
2W
3
7a
3
5b
7b
6g
6f
PWL
5a
NWL
2S
3

FIG.31

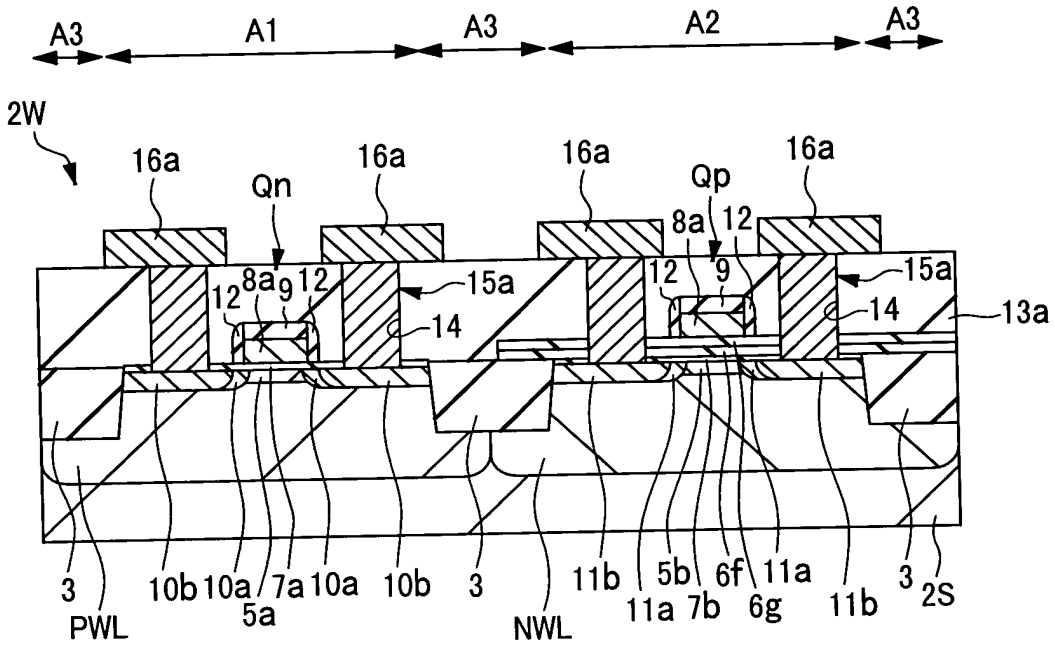
A3
A1
A3
A2
A3
2W
16a
Qn
16a
16a
Qp
16a
8a
12
12
8a
9
12
12
9
15a
15a
14
14
13a
3
PWL
10b
10a
5a
7a
10a
10b
3
NWL
11b
11a
5b
7b
6f
6g
11a
11b
3
2S

FIG.32

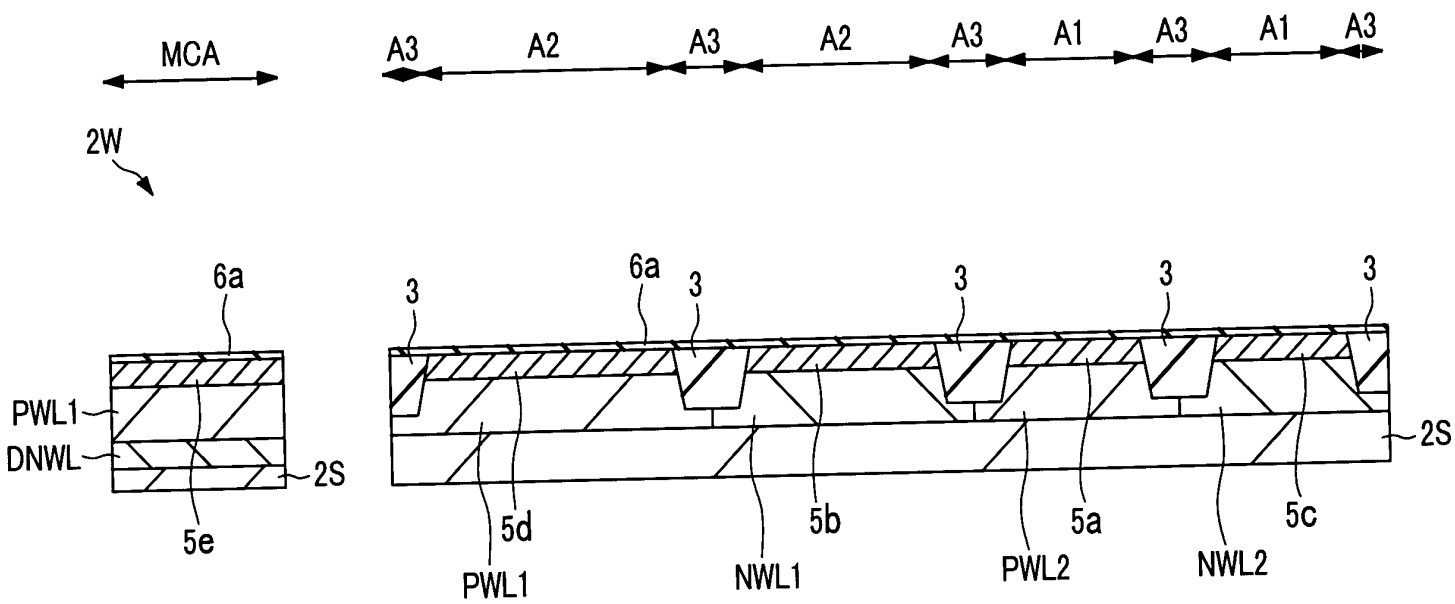
MCA
A3
A2
A3
A2
A3
A1
A3
A1
A3
2W
6a
PWL1
DNWL
2S
5e
3
6a
3
3
3
3
2S
5d
PWL1
NWL1
5b
PWL2
5a
NWL2
5c

FIG.33

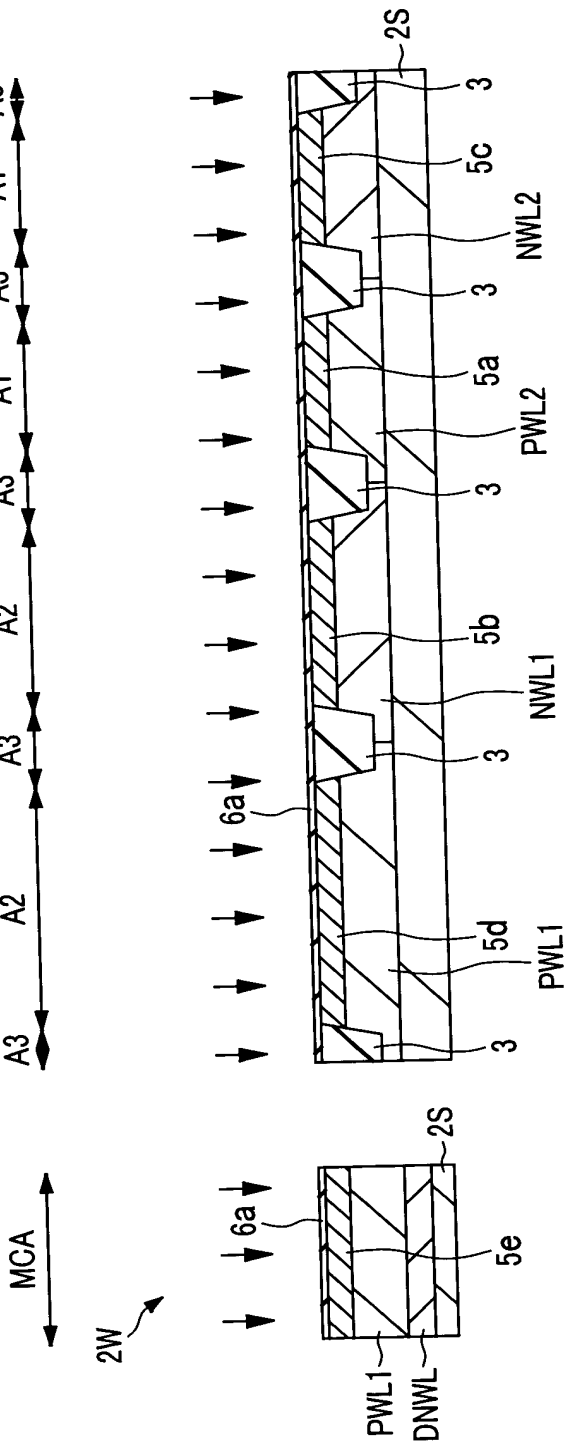
A3
A2
A3
A2
A3
A1
A3
A1
A3
A1
A3
MCA
2W
6a
6a
2S
2S
5e
PWL1
DNWL
3
3
3
3
3
5d
5b
5a
5c
PWL1
NWL1
PWL2
NWL2

FIG.34

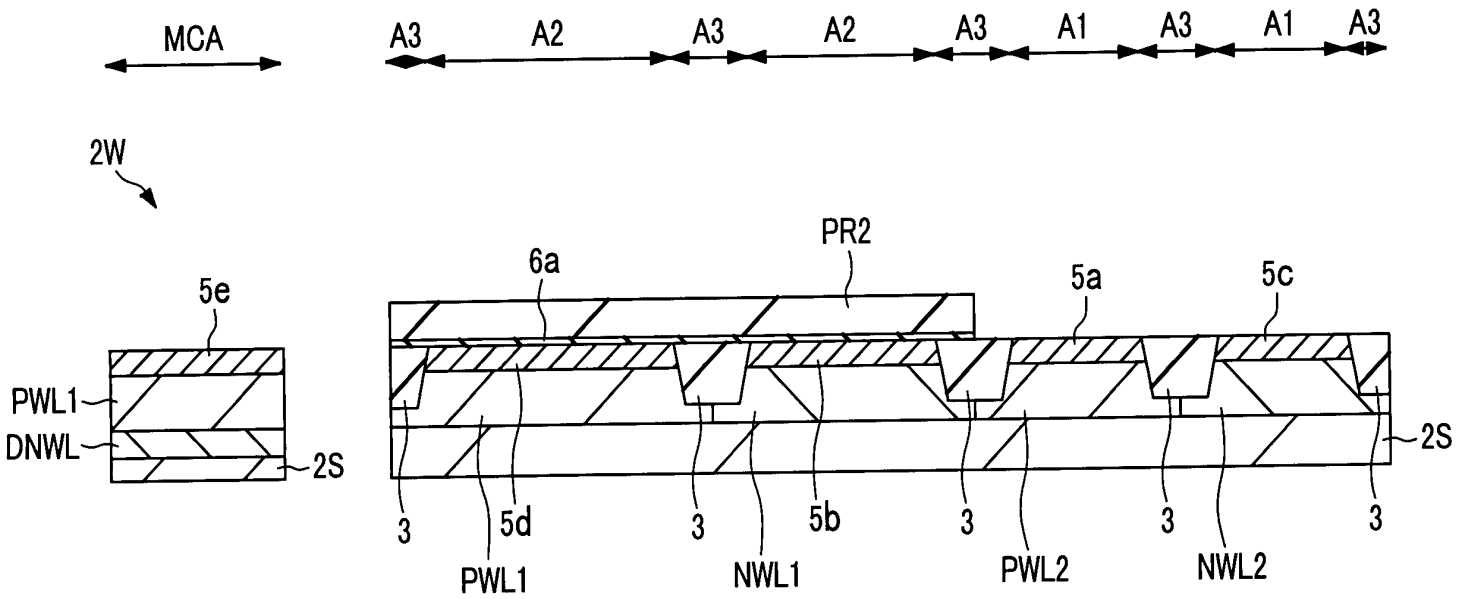
MCA
A3
A2
A3
A2
A3
A1
A3
A1
A3
2W
PR2
6a
5e
5a
5c
PWL1
DNWL
2S
2S
3
5d
3
5b
3
3
3
PWL1
NWL1
PWL2
NWL2

FIG.35

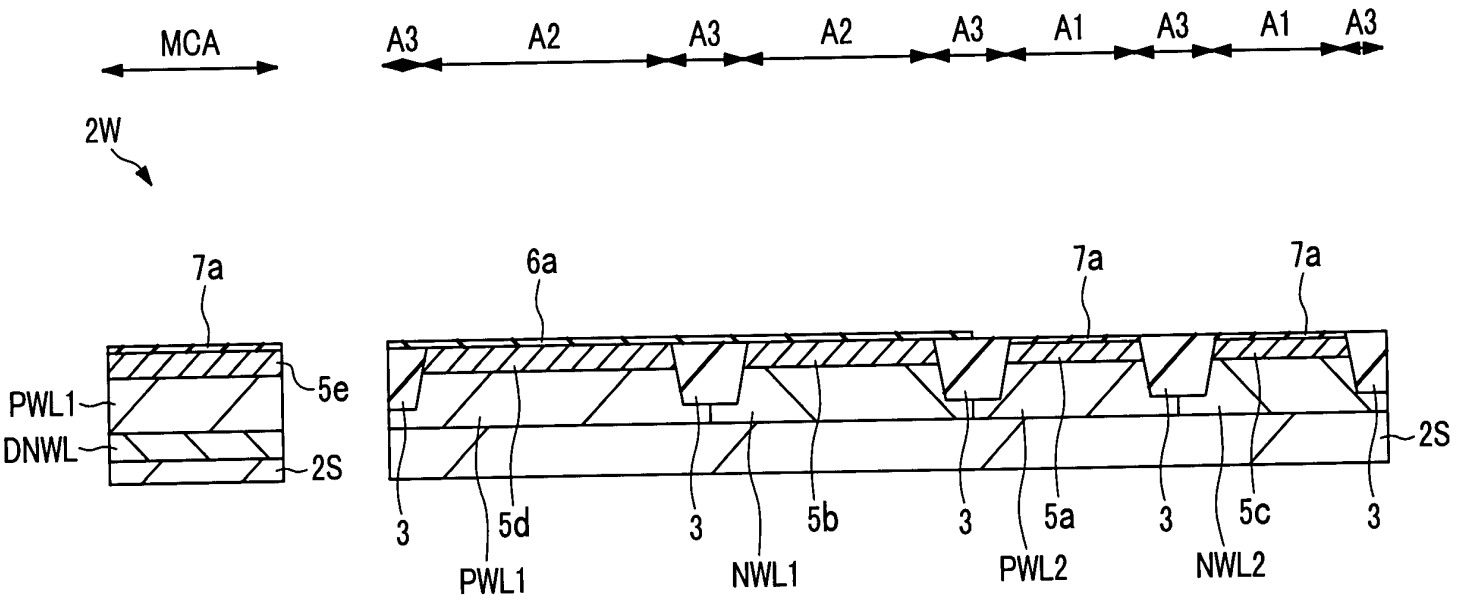
MCA
A3
A2
A3
A2
A3
A1
A3
A1
A3
2W
7a
6a
7a
7a
PWL1
DNWL
5e
2S
2S
3
5d
PWL1
3
5b
NWL1
3
5a
PWL2
3
5c
NWL2
3

FIG.36

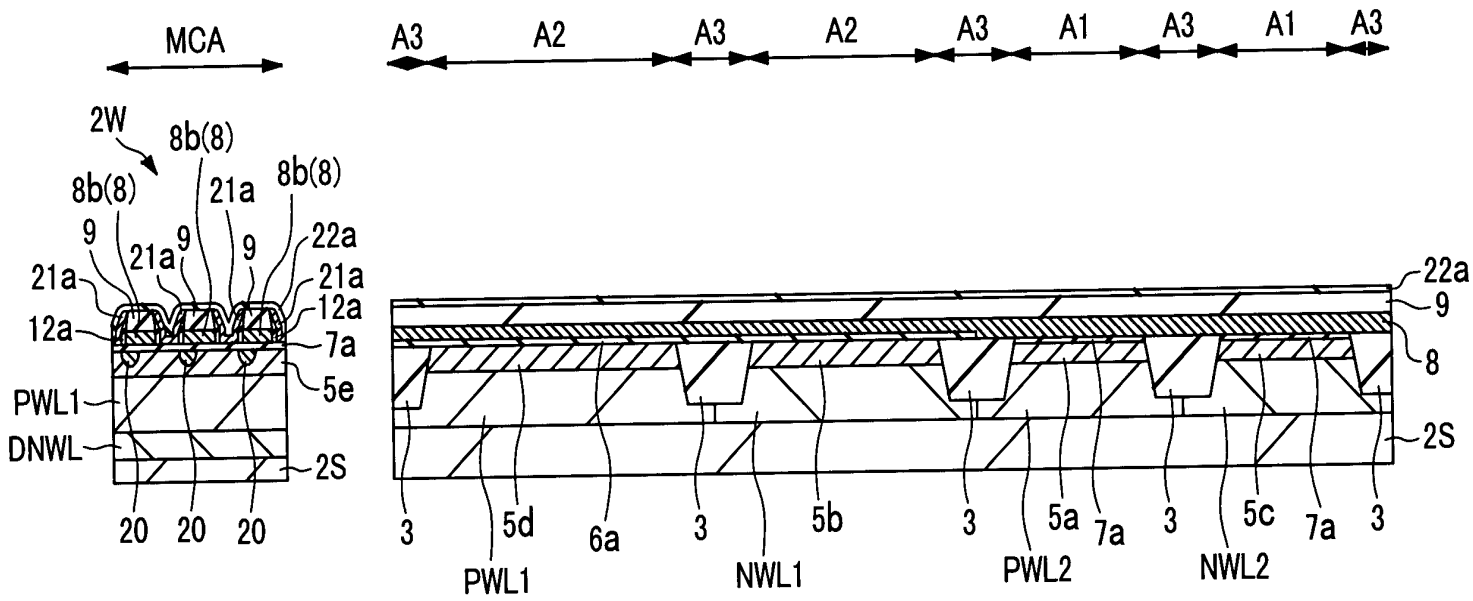
MCA
A3
A2
A3
A2
A3
A1
A3
A1
A3
2W
8b(8)
8b(8)
21a
8b(8)
9
21a
9
9
22a
21a
21a
12a
12a
7a
5e
PWL1
DNWL
2S
20
20
20
22a
9
8
2S
3
5d
6a
3
5b
3
5a
7a
3
5c
7a
3
PWL1
NWL1
PWL2
NWL2

FIG.37

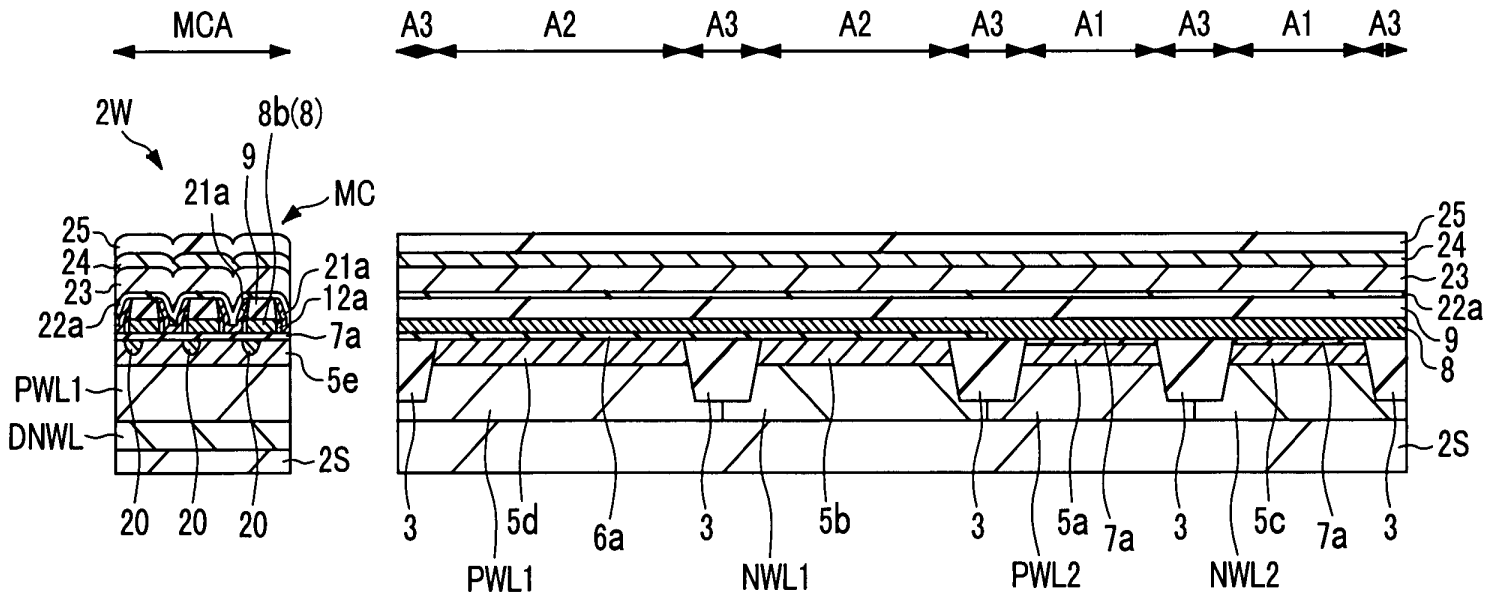
MCA
A3
A2
A3
A2
A3
A1
A3
A1
A3
2W
8b(8)
9
21a
MC
25
24
23
22a
21a
12a
7a
5e
PWL1
DNWL
2S
20
20
20
25
24
23
22a
9
8
2S
3
5d
6a
3
5b
3
5a
7a
3
5c
7a
3
PWL1
NWL1
PWL2
NWL2

FIG.38

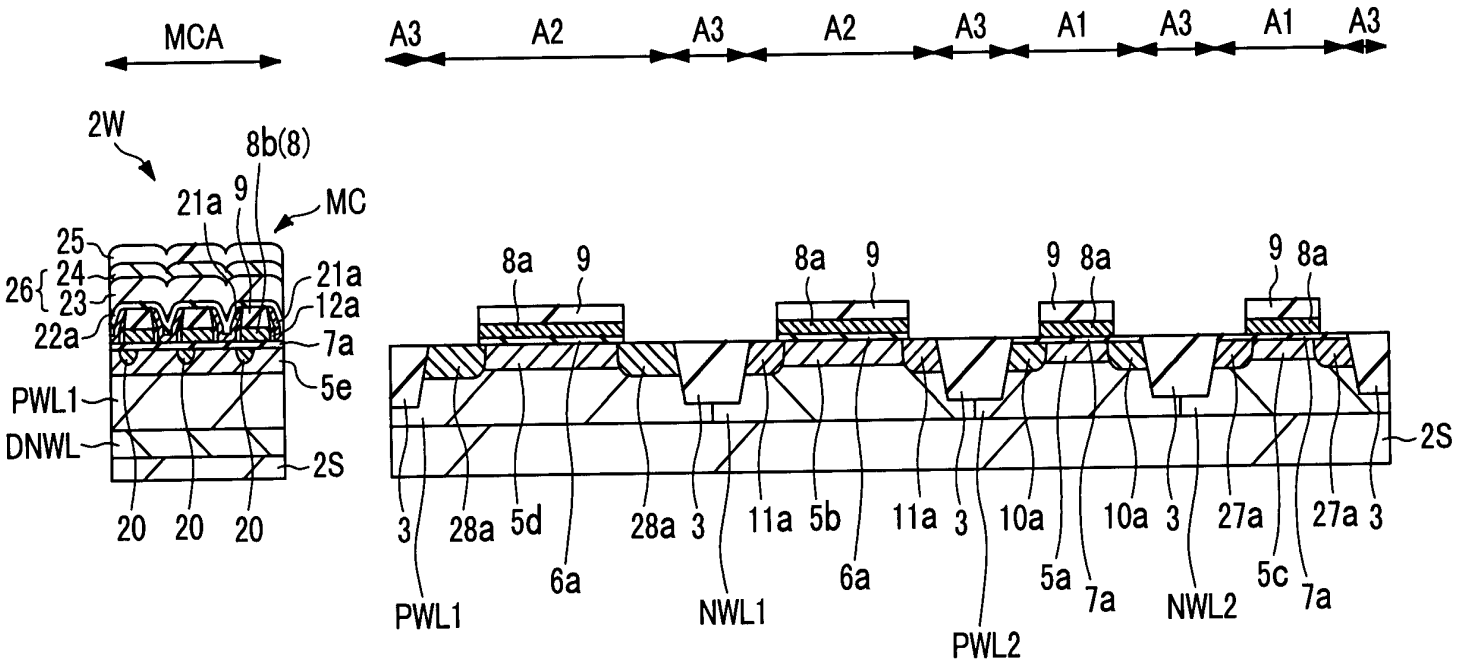
MCA
A3
A2
A3
A2
A3
A1
A3
A1
A3
2W
8b(8)
21a
9
MC
25
24
26
23
22a
21a
12a
7a
5e
PWL1
DNWL
2S
20
20
20
8a
9
8a
9
9
8a
9
8a
2S
3
28a
5d
6a
28a
3
11a
5b
6a
11a
3
10a
10a
3
27a
27a
3
PWL1
NWL1
PWL2
5a
7a
NWL2
5c
7a

FIG.39

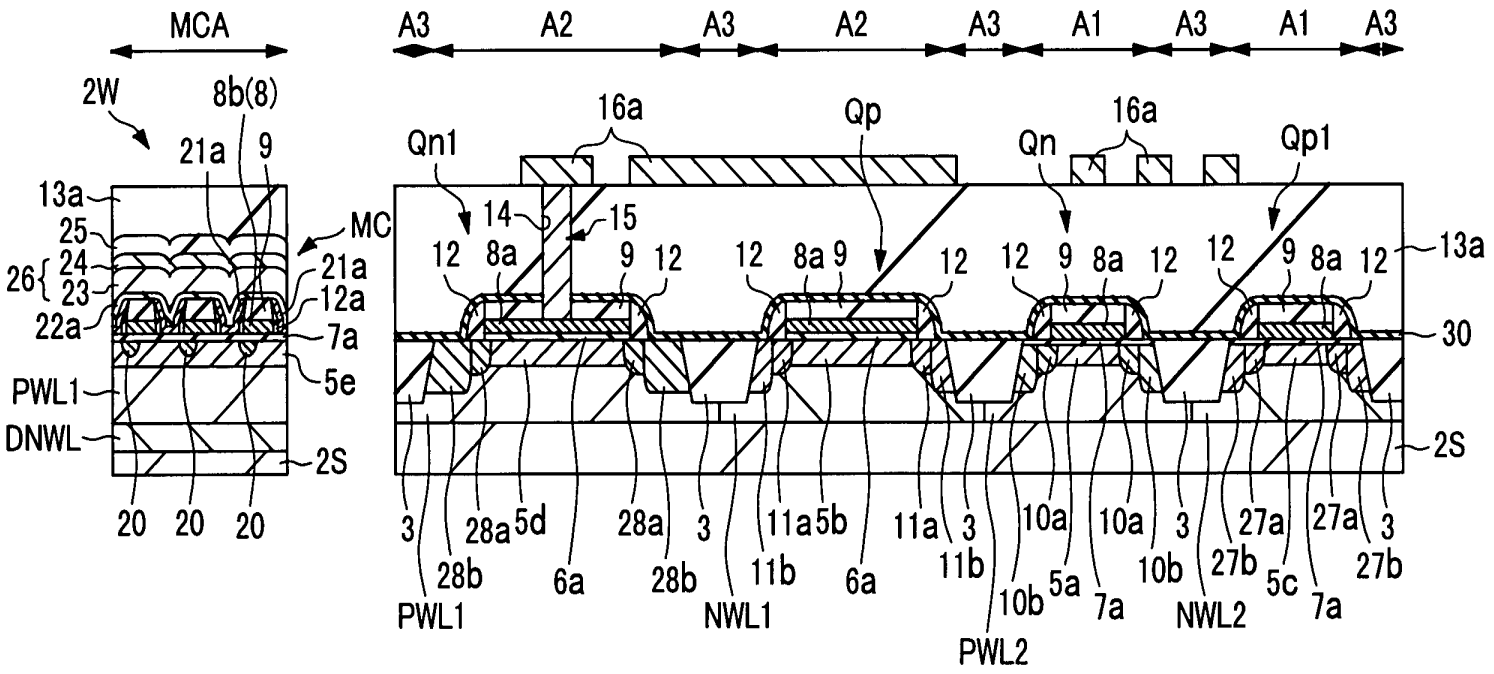
MCA
A3
A2
A3
A2
A3
A1
A3
A1
A3
2W
8b(8)
21a
9
16a
Qp
16a
Qn1
Qn
Qp1
13a
25
24
23
22a
26
MC
21a
12a
7a
5e
PWL1
DNWL
2S
14
15
12
8a
9
30
20
20
20
3
28b
28a
5d
6a
11a
5b
11b
10b
5a
10a
7a
10b
27b
5c
27a
PWL1
NWL1
PWL2
NWL2

FIG.40

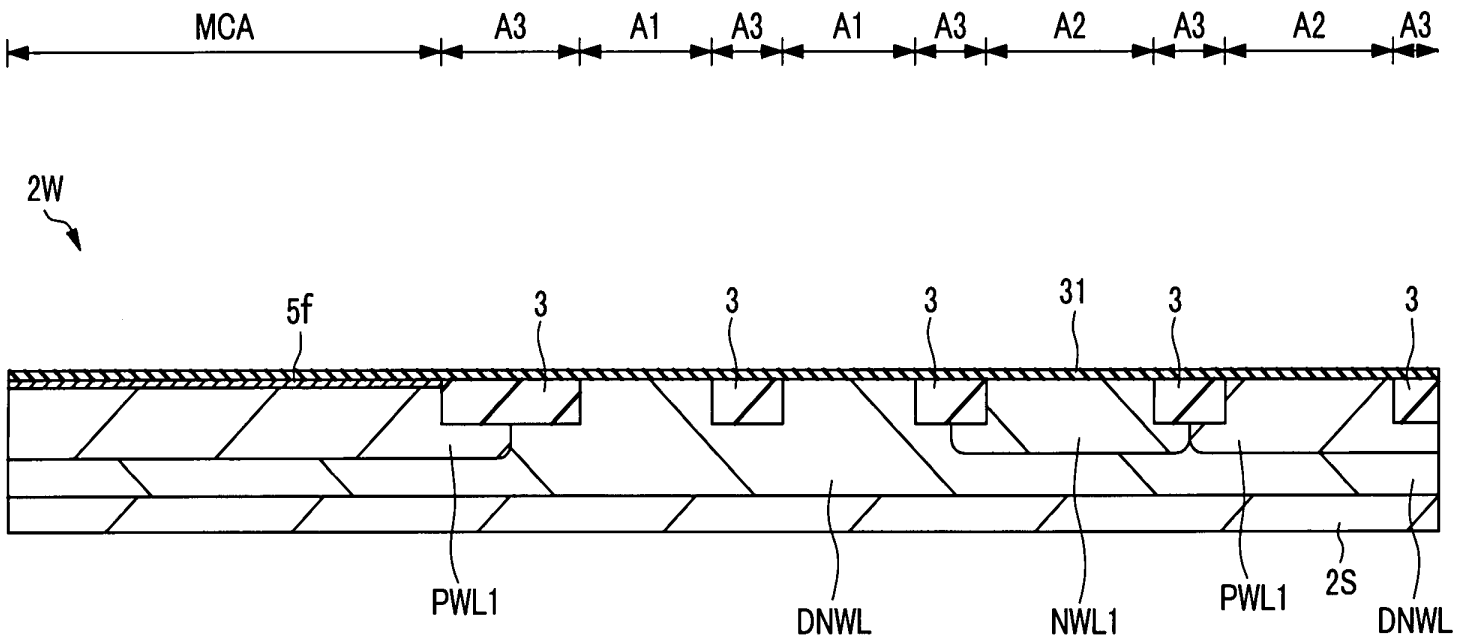
MCA
A3
A1
A3
A1
A3
A2
A3
A2
A3
2W
5f
3
3
3
31
3
3
PWL1
DNWL
NWL1
PWL1
2S
DNWL

FIG.41

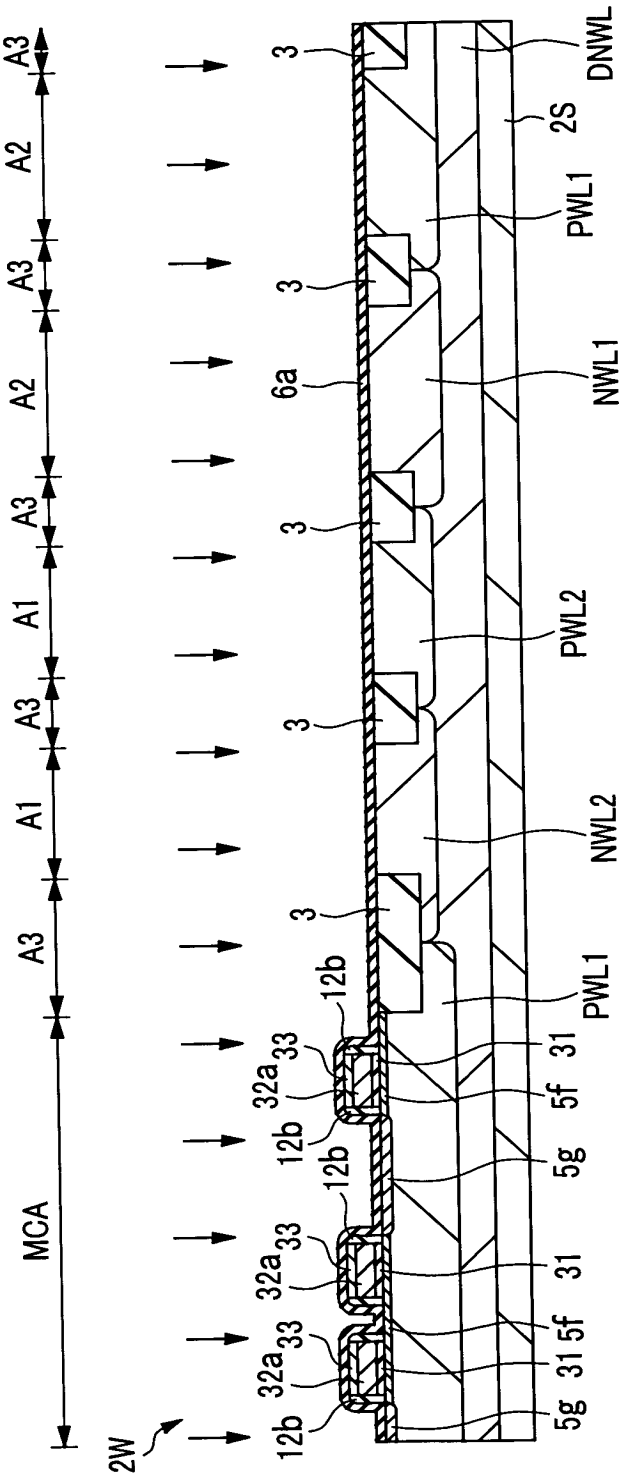
A3
A2
A3
A2
A3
A1
A3
A1
A3
MCA
2W
12b
32a
33
31
5f
5g
3
6a
PWL1
PWL2
NWL1
NWL2
2S
DNWL

FIG.42

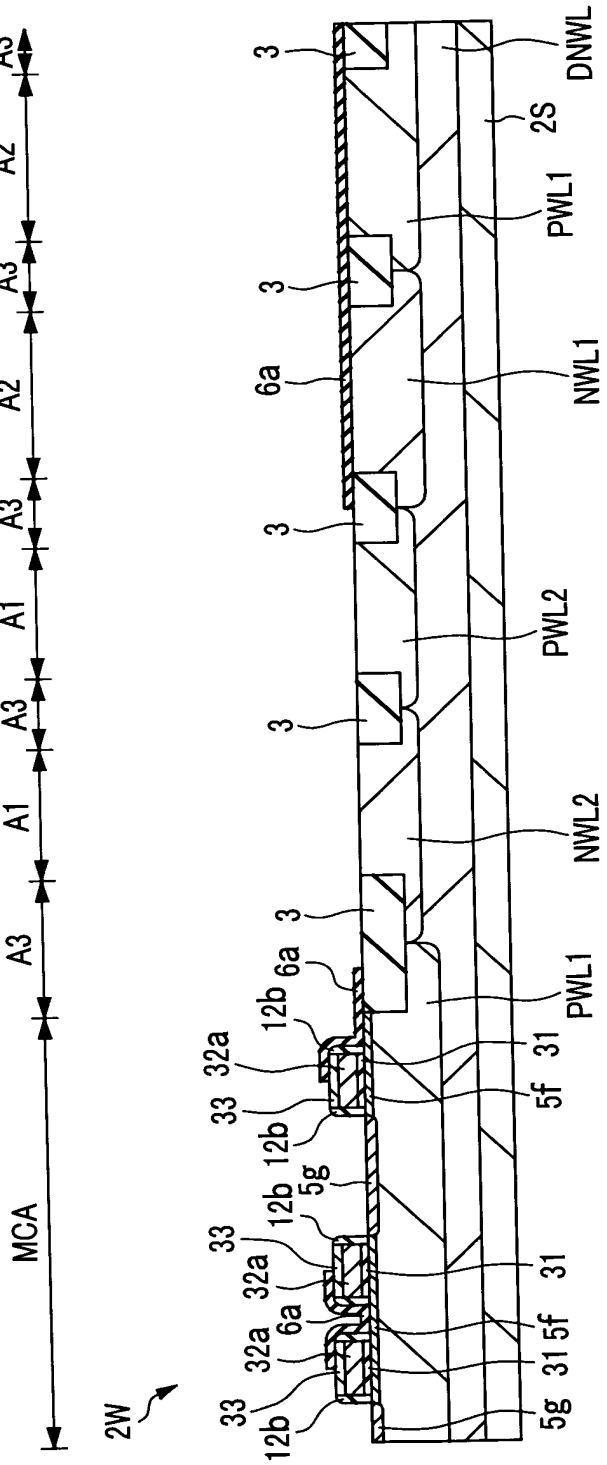
A3
A1
A3
A1
A3
A2
A3
A2
A3
MCA
2W
3
6a
12b
32a
33
5g
31
5f
PWL1
PWL2
NWL1
NWL2
2S
DNWL

FIG.43

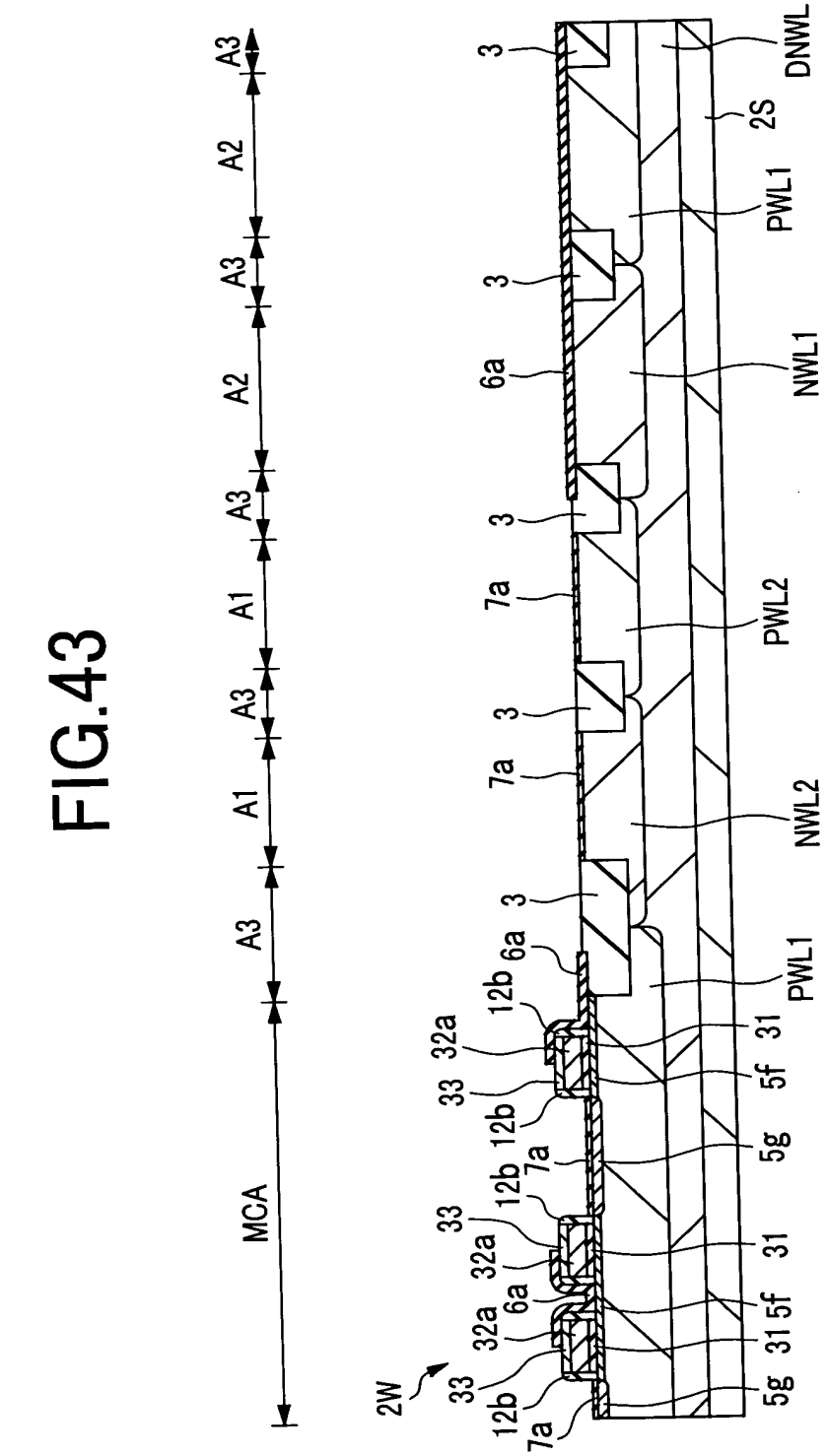
A3
A2
A3
A2
A3
A1
A3
A1
A3
MCA
2W
33
12b
7a
32a
6a
31
5g
5f
12b
33
32a
12b
7a
33
12b
6a
3
7a
3
7a
3
6a
3
3
DNWL
2S
PWL1
NWL1
PWL2
NWL2
PWL1

FIG.44

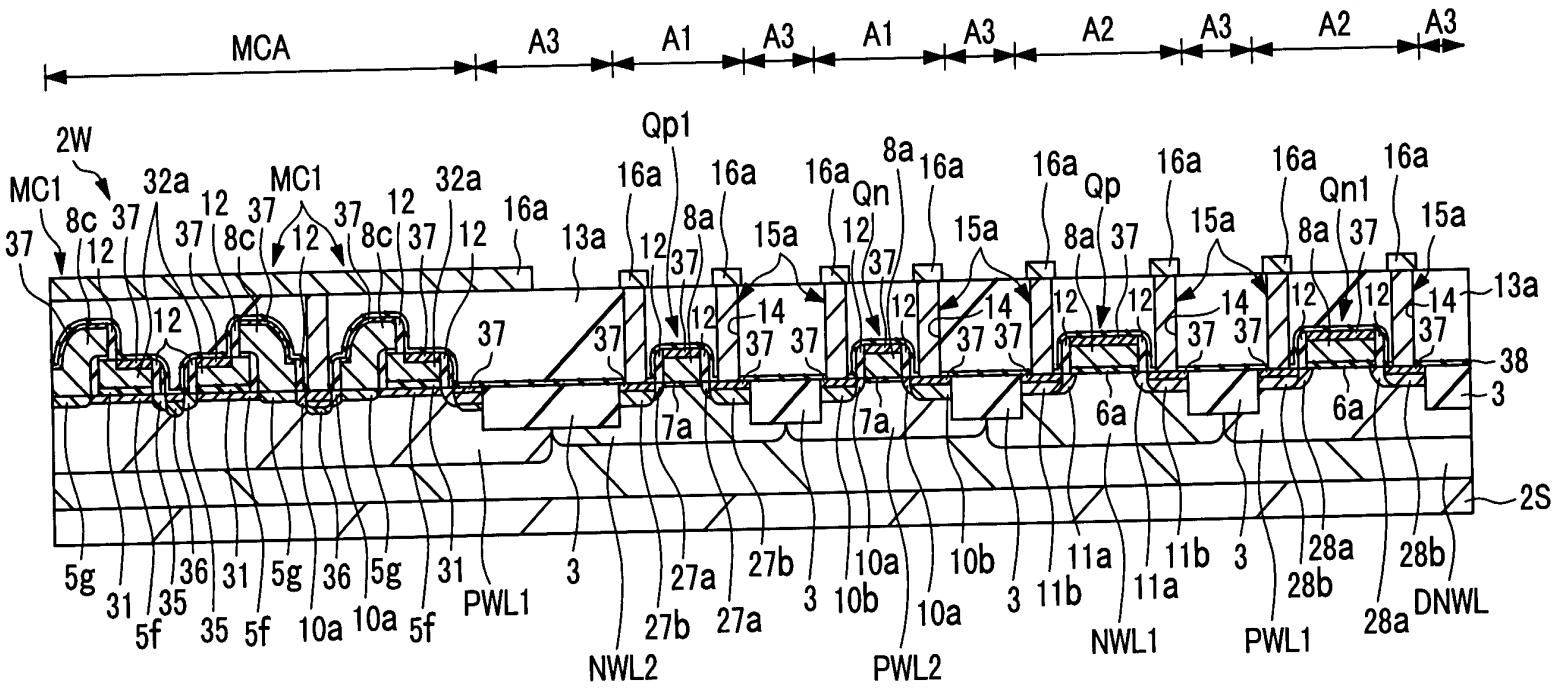
MCA
A3
A1
A3
A1
A3
A2
A3
A2
A3
2W
MC1
32a
MC1
32a
16a
13a
Qp1
16a
16a
16a
8a
16a
16a
Qp
16a
16a
Qn1
16a
Qn
8c
12
37
15a
14
38
3
2S
7a
6a
5g
31
5f
36
35
31
5f
5g
36
10a
5g
10a
31
5f
PWL1
3
NWL2
27a
27b
27b
27a
3
10a
10b
10a
PWL2
3
10b
11a
11b
11a
NWL1
3
28a
28b
28b
28a
DNWL
PWL1

FIG.45

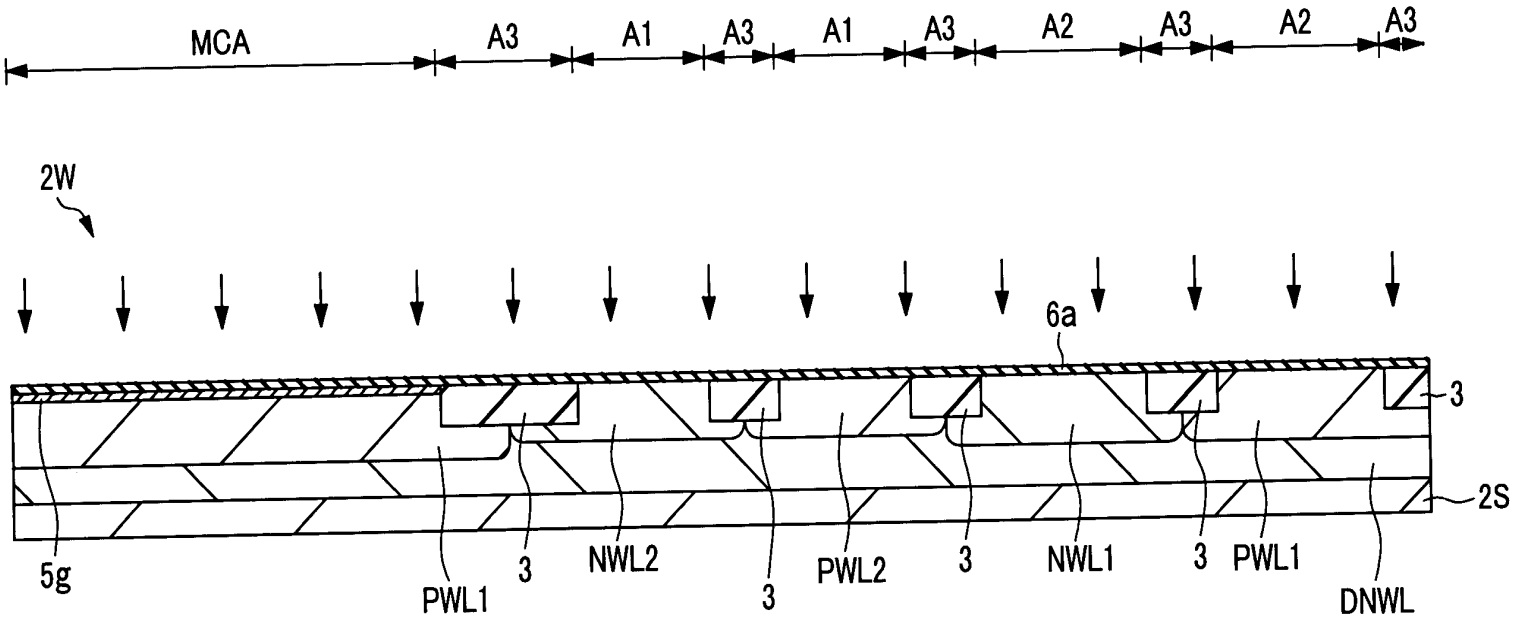
MCA
A3
A1
A3
A1
A3
A2
A3
A2
A3
2W
6a
3
2S
5g
PWL1
3
NWL2
3
PWL2
3
NWL1
3
PWL1
DNWL

FIG.46

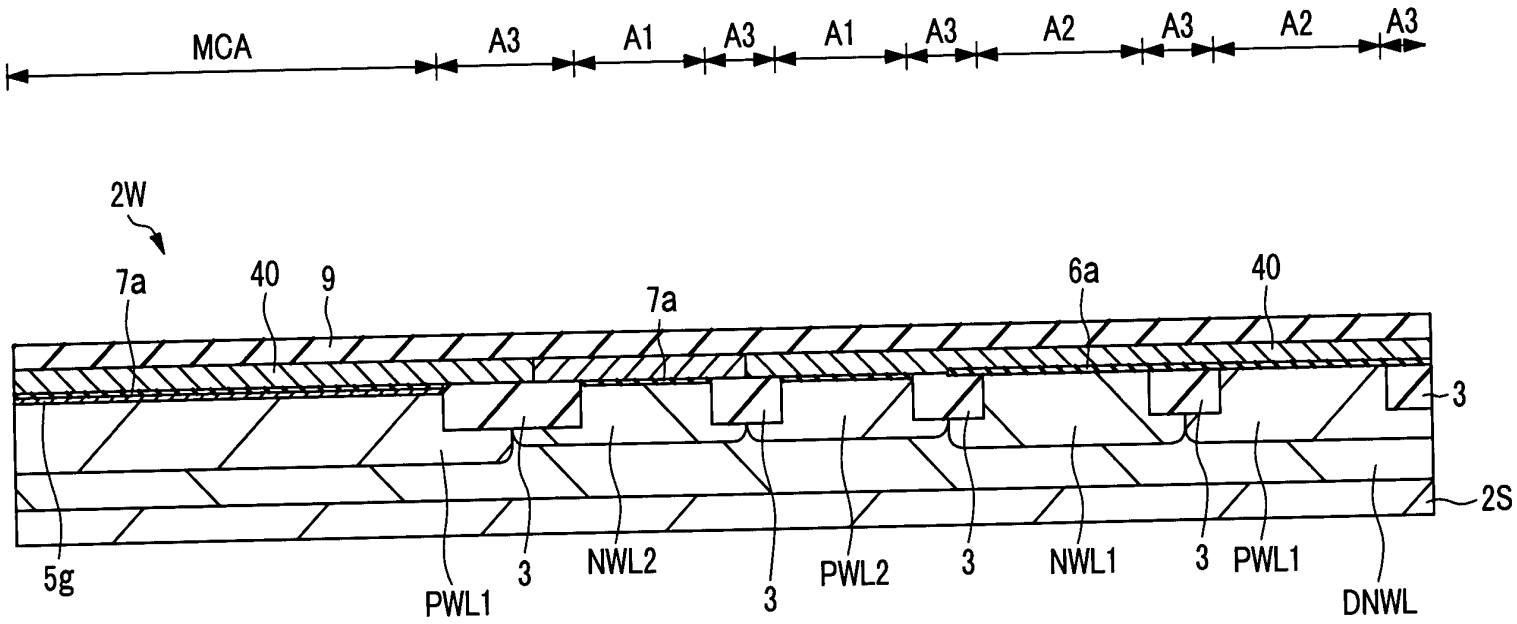
MCA
A3
A1
A3
A1
A3
A2
A3
A2
A3
2W
7a
40
9
7a
6a
40
3
2S
5g
PWL1
3
NWL2
3
PWL2
3
NWL1
3
PWL1
DNWL

FIG.47

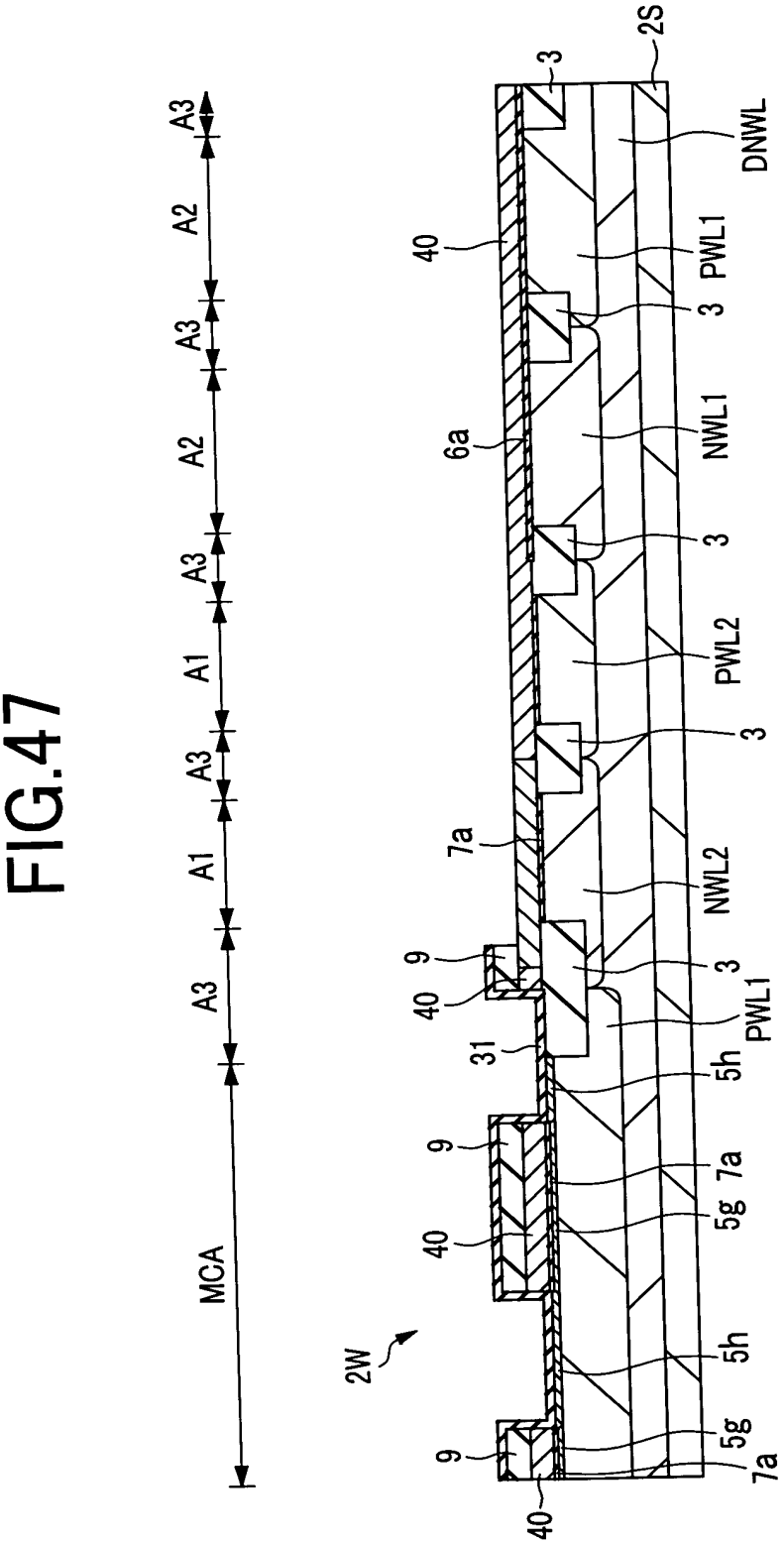
A3
A2
A3
A2
A3
A1
A3
A1
A3
MCA
2S
3
DNWL
40
PWL1
3
6a
NWL1
3
PWL2
3
7a
NWL2
9
40
3
PWL1
31
5h
9
7a
40
5g
5h
2W
9
5g
7a
40

FIG.48

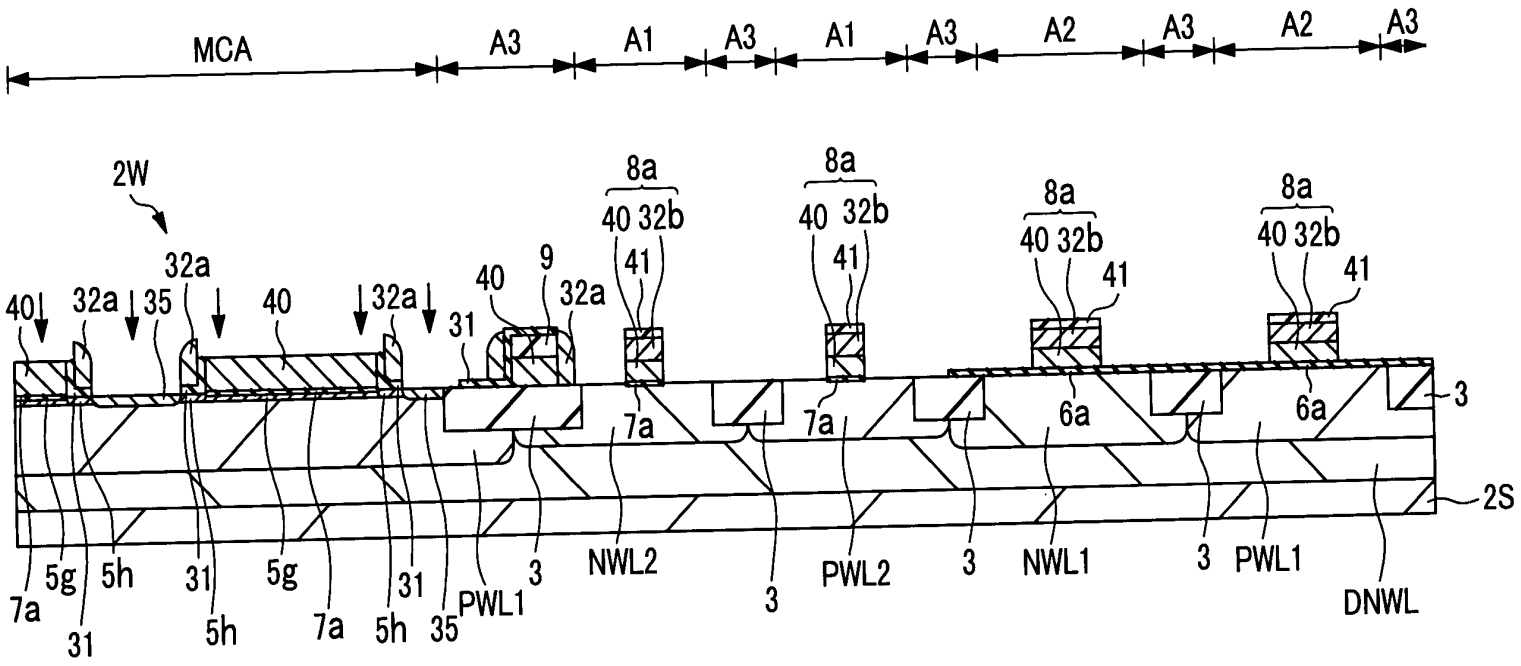
MCA
A3
A1
A3
A1
A3
A2
A3
A2
A3
2W
8a
40 32b
41
9
32a
35
31
3
6a
7a
5g
5h
NWL2
PWL2
NWL1
PWL1
DNWL
2S

FIG.49

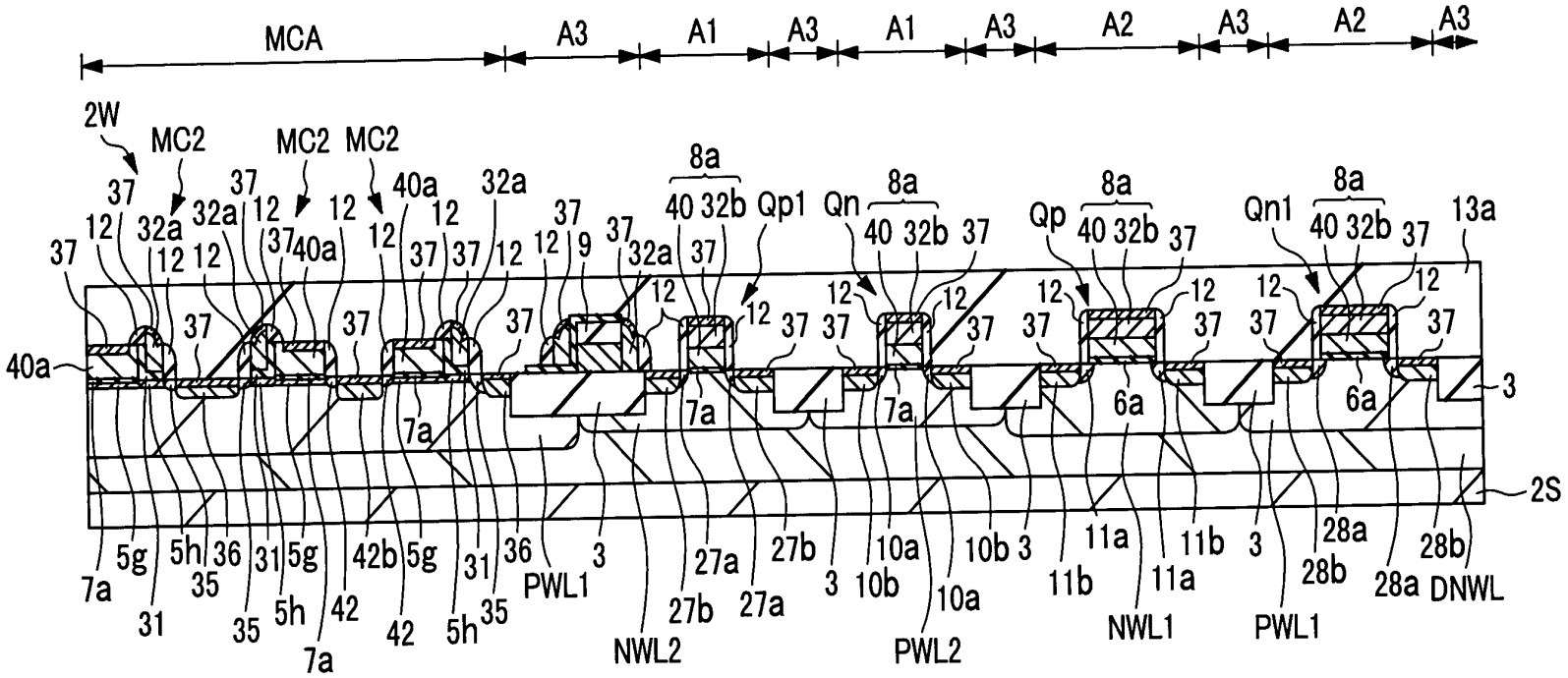
MCA
A3
A1
A3
A1
A3
A2
A3
A2
A3
2W
MC2
MC2
MC2
8a
Qp1
Qn
Qp
Qn1
13a
40a
3
7a
6a
2S
PWL1
NWL2
PWL2
NWL1
DNWL

FIG.50

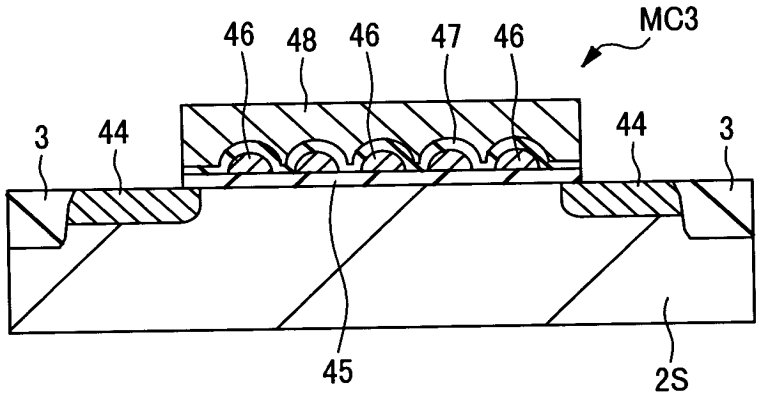

FIG.51

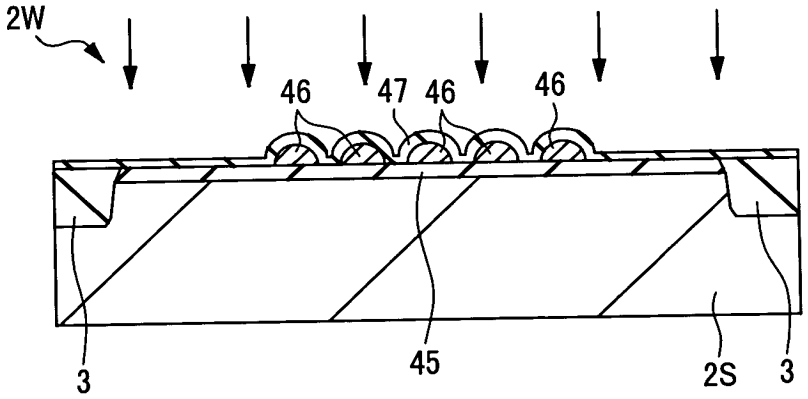

FIG.52

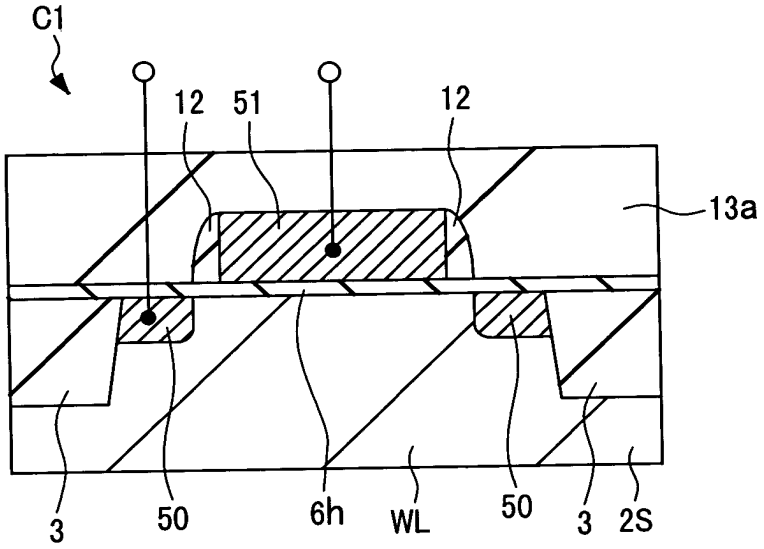

FIG.53

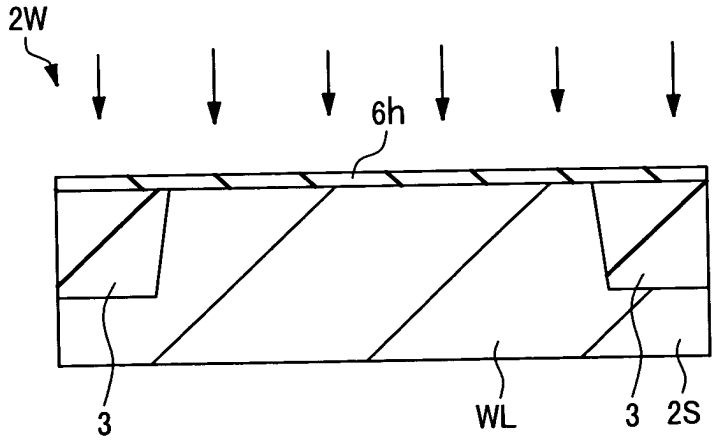

FIG.54

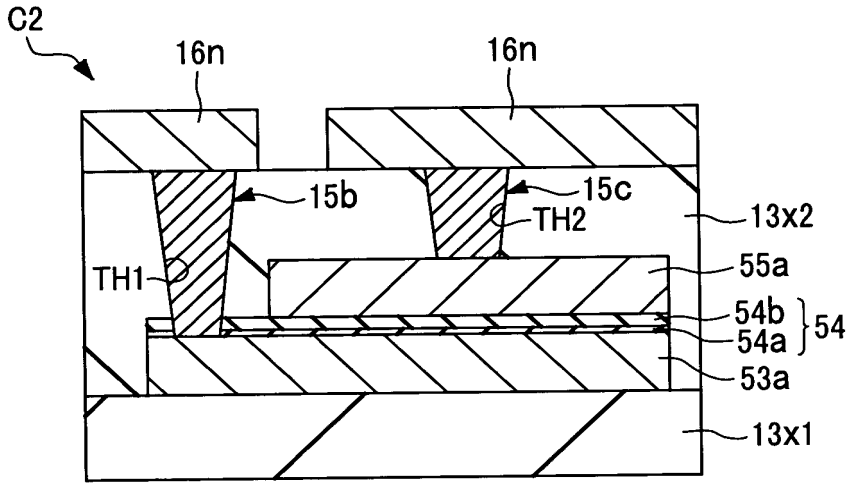
C2
16n
16n
15b
15c
TH2
13x2
TH1
55a
54b
54a
54
53a
13x1

FIG.55

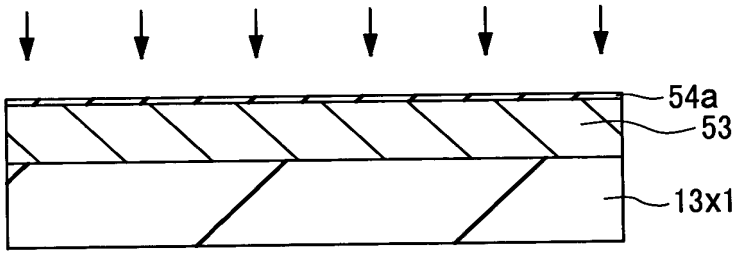
54a
53
13x1

FIG.56

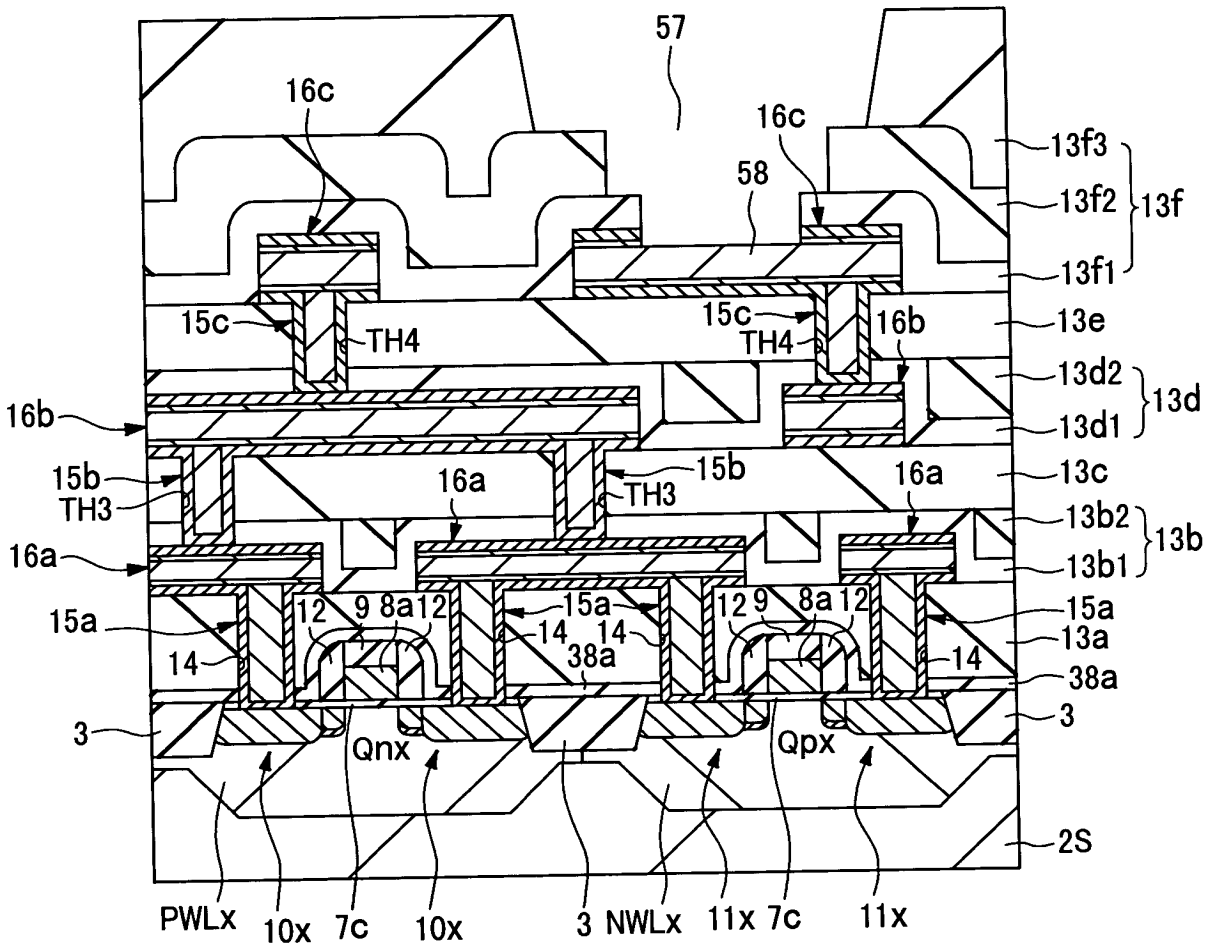
57
16c
16c
58
13f3
13f2
13f
13f1
15c
TH4
15c
TH4
16b
13e
13d2
13d
13d1
16b
15b
TH3
16a
15b
TH3
16a
13c
13b2
13b
13b1
16a
15a
12
9
8a
12
15a
14
14
38a
12
9
8a
12
15a
13a
14
14
38a
3
3
Qnx
Qpx
2S
PWLx
10x
7c
10x
3
NWLx
11x
7c
11x

FIG.57

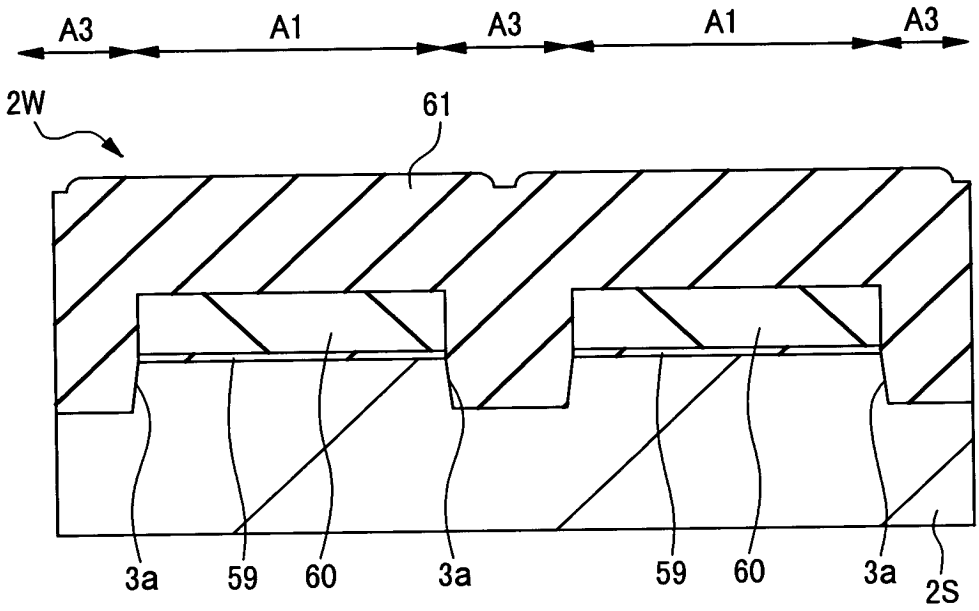
A3
A1
A3
A1
A3
2W
61
3a
59
60
3a
59
60
3a
2S

FIG.58

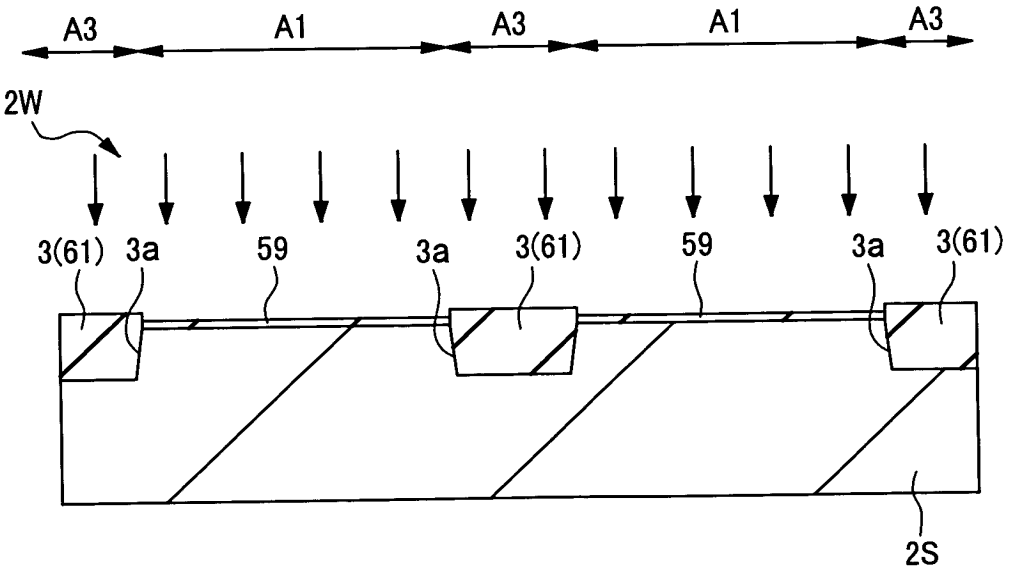
A3
A1
A3
A1
A3
2W
3(61)
3a
59
3a
3(61)
59
3a
3(61)
2S

FIG.59

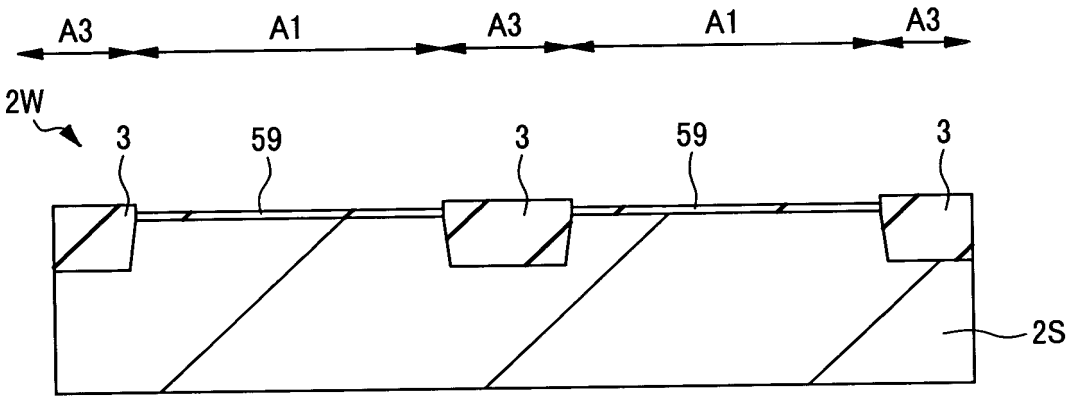

FIG.60

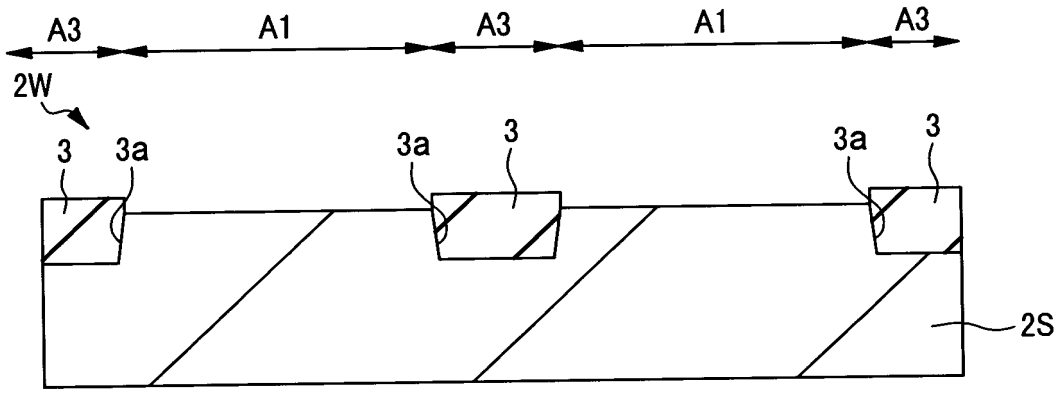

FIG.61

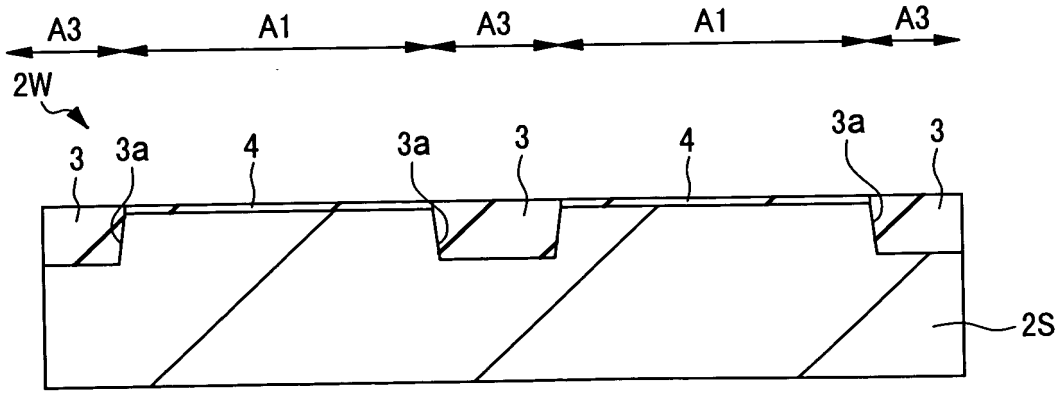

FIG.62

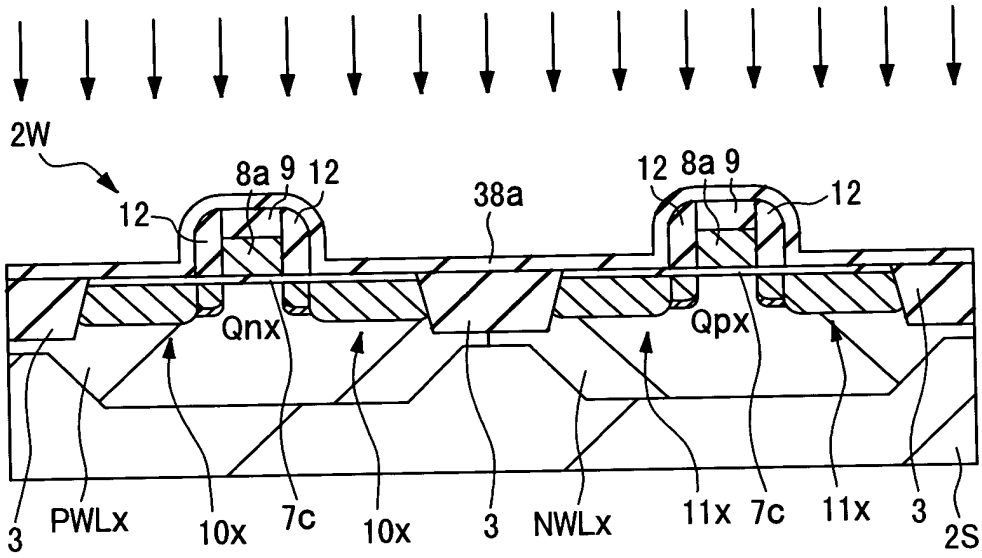
2W
12
8a 9 12
38a
12 8a 9
12
Qnx
Qpx
3
PWLx
10x
7c
10x
3
NWLx
11x 7c
11x
3
2S

FIG.63

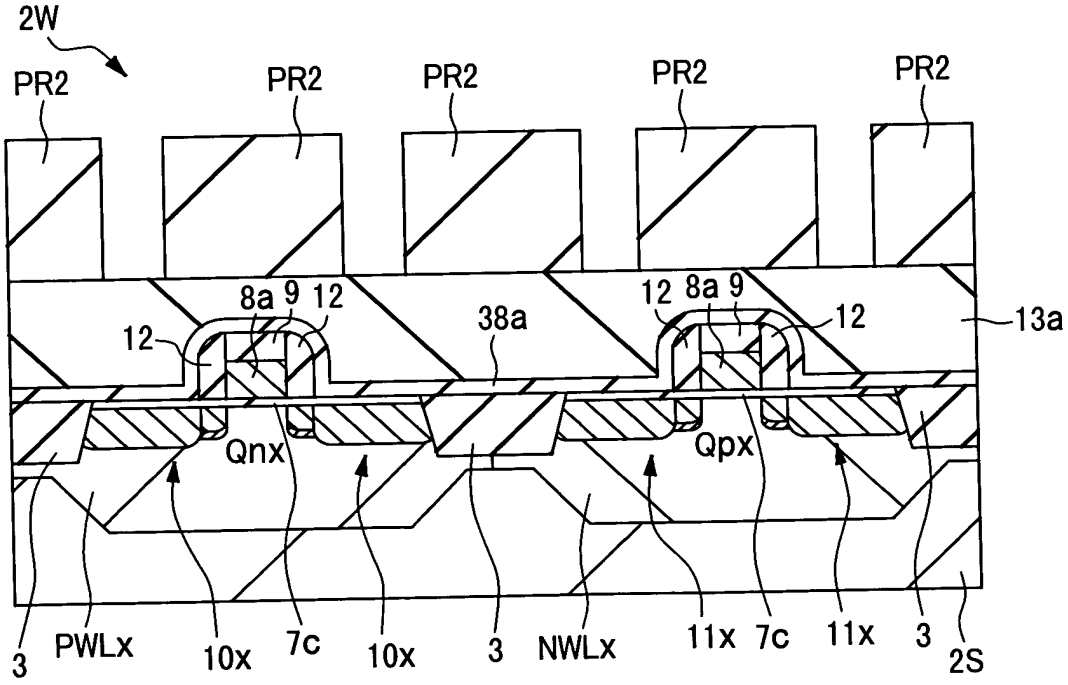
2W
PR2
PR2
PR2
PR2
PR2
8a 9 12
12
38a
12 8a 9
12
13a
Qnx
Qpx
3
PWLx
10x
7c
10x
3
NWLx
11x 7c
11x
3
2S

FIG.64

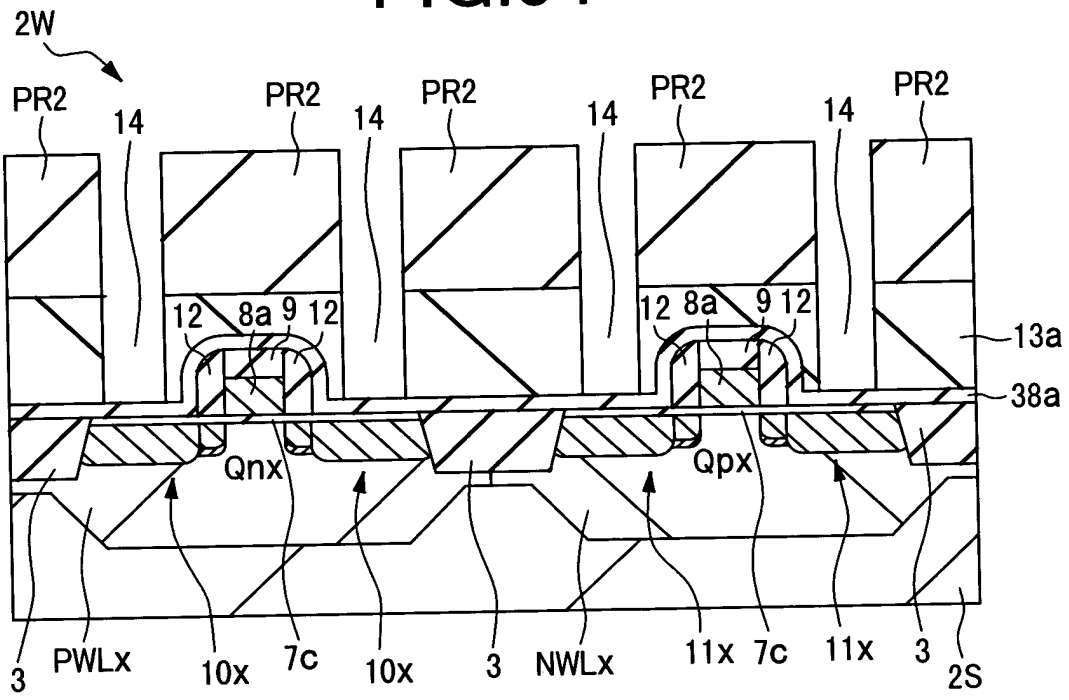
2W
PR2
14
12
8a
9
13a
38a
Qnx
Qpx
3
PWLx
10x
7c
NWLx
11x
2S

FIG.65

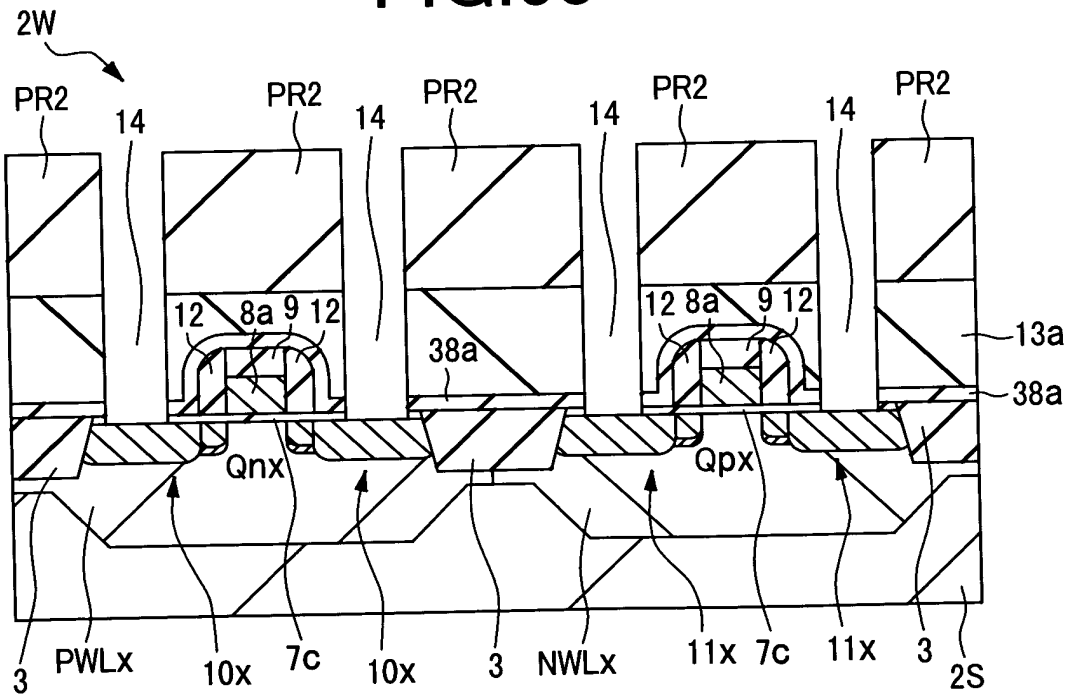
2W
PR2
14
12
8a
9
38a
13a
Qnx
Qpx
3
PWLx
10x
7c
NWLx
11x
2S

FIG.66

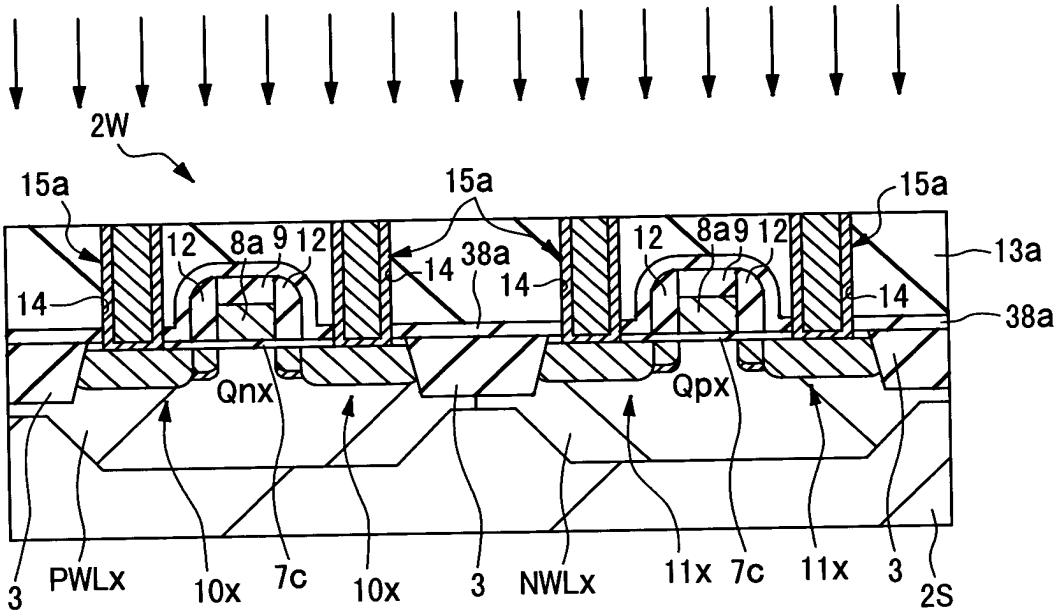
2W
15a
15a
15a
12
8a
9
12
14
38a
14
12
8a
9
12
13a
14
14
38a
Qnx
Qpx
3
PWLx
10x
7c
10x
3
NWLx
11x
7c
11x
3
2S

FIG.67

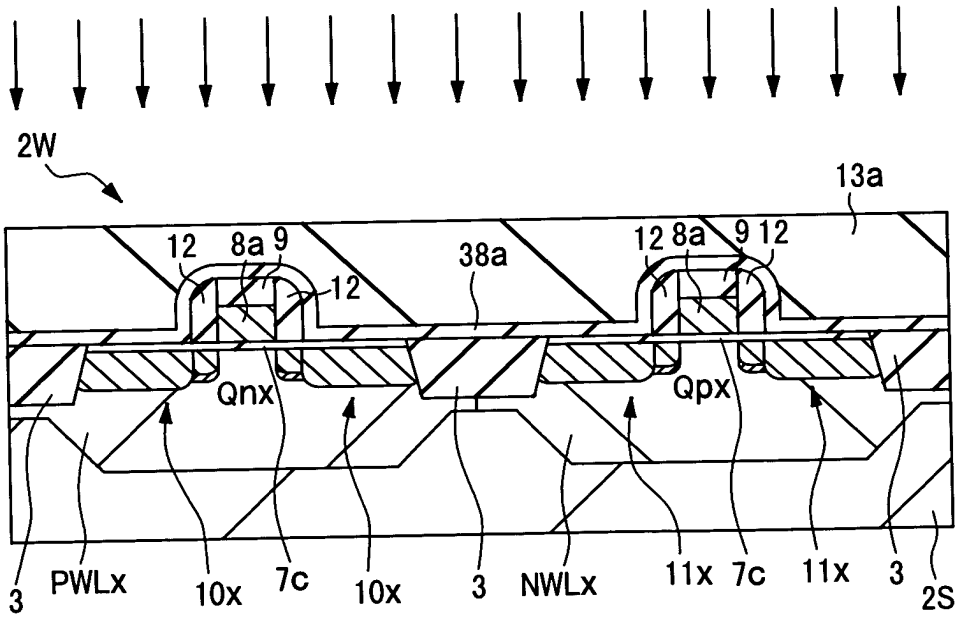
2W
13a
12
8a
9
12
38a
12
8a
9
12
Qnx
Qpx
3
PWLx
10x
7c
10x
3
NWLx
11x
7c
11x
3
2S

FIG.68

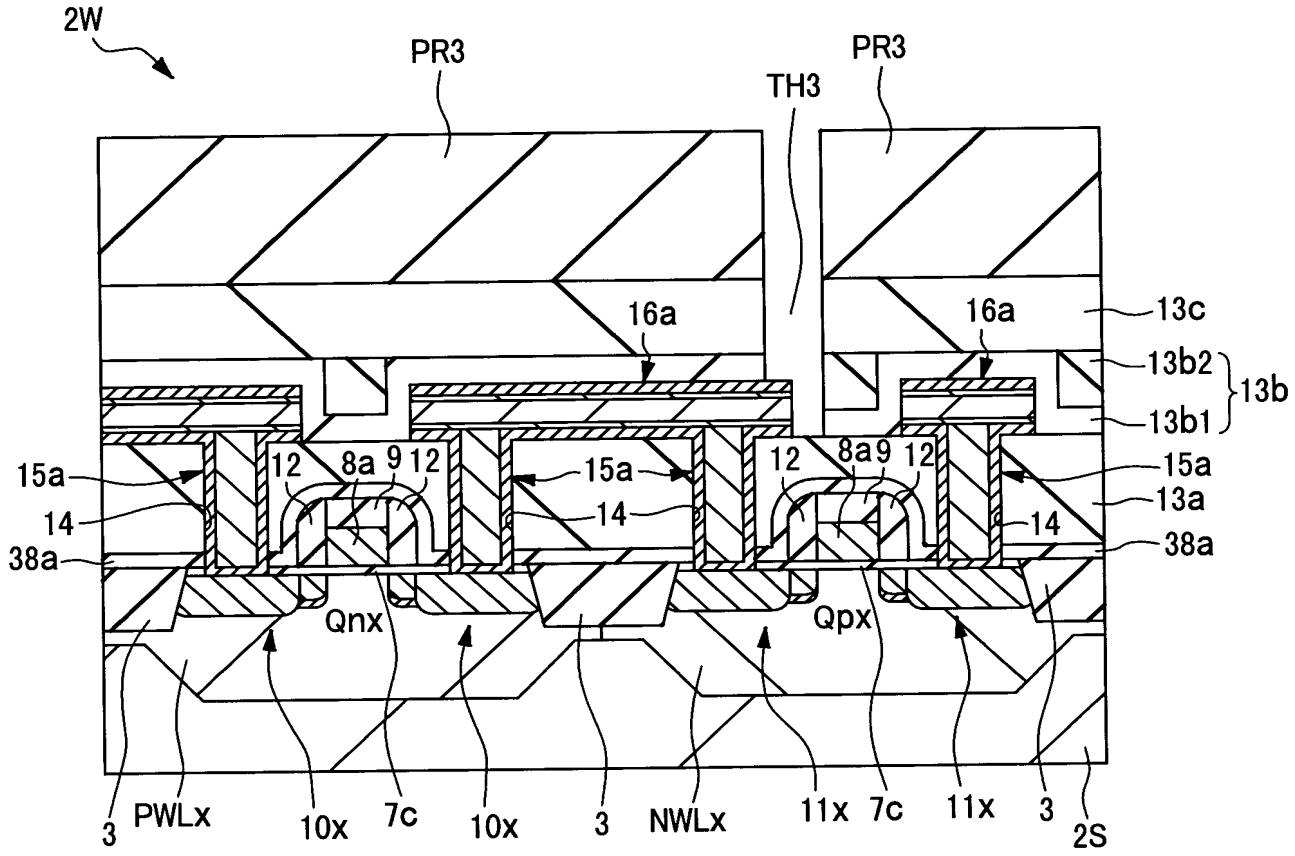
2W
PR3
TH3
PR3
16a
16a
13c
13b2
13b
13b1
15a
12
8a
9
12
15a
12
8a
9
12
15a
14
14
14
13a
38a
38a
Qnx
Qpx
3
PWLx
10x
7c
10x
3
NWLx
11x
7c
11x
3
2S

FIG.69

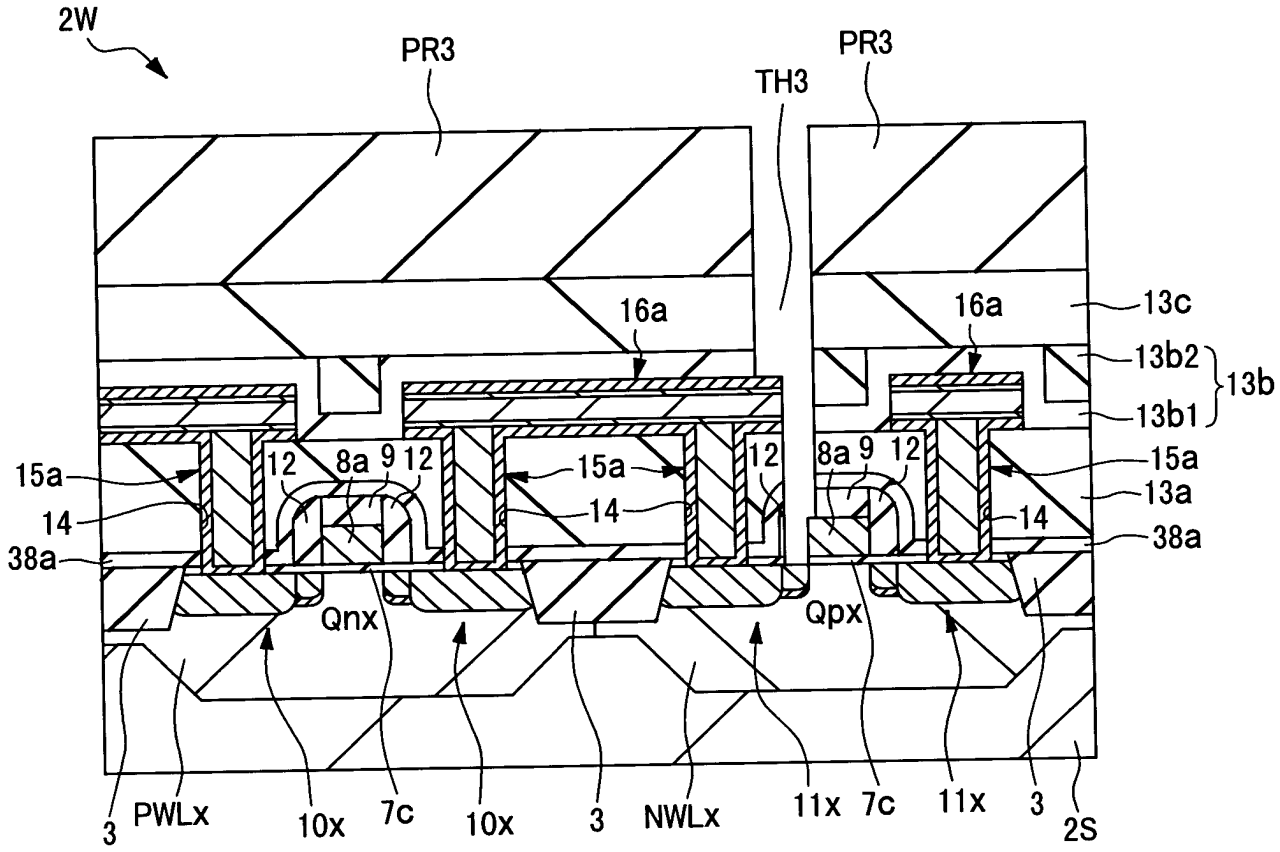
2W
PR3
TH3
PR3
16a
16a
13c
13b2
13b
13b1
15a
12
8a
9
12
15a
12
8a
9
12
15a
14
14
13a
14
38a
38a
Qnx
Qpx
3
PWLx
10x
7c
10x
3
NWLx
11x
7c
11x
3
2S

FIG.70

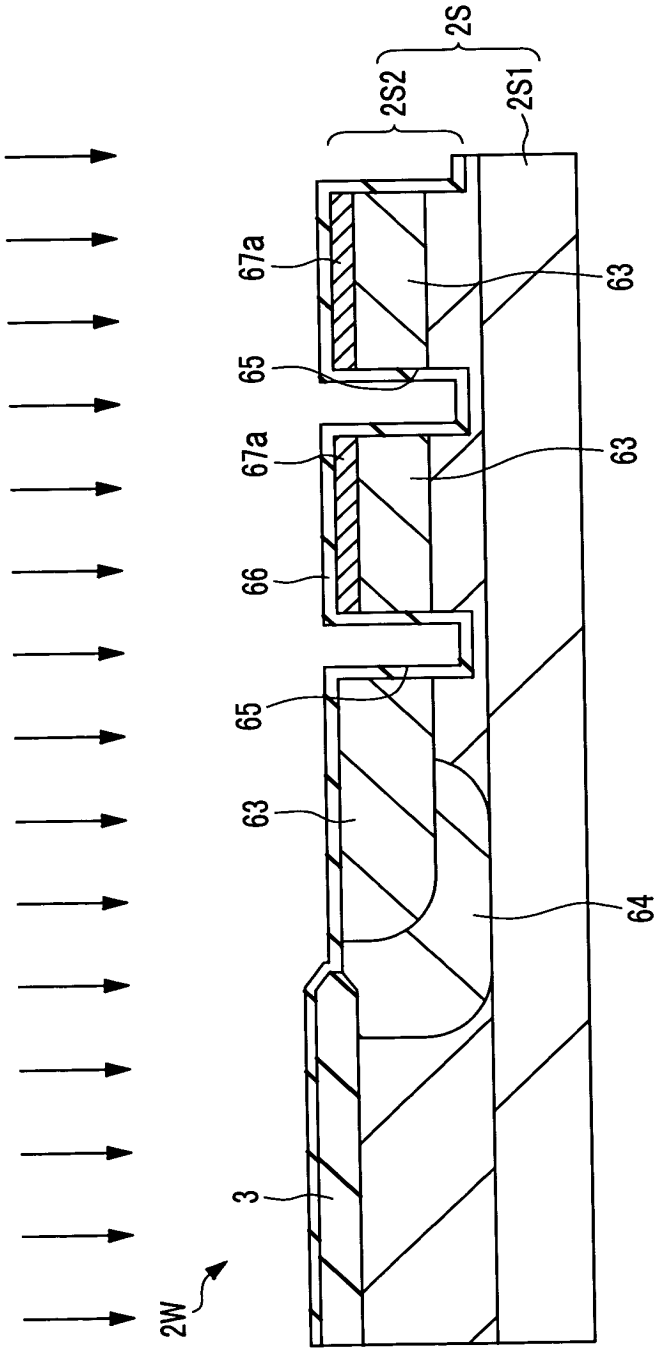

FIG.71

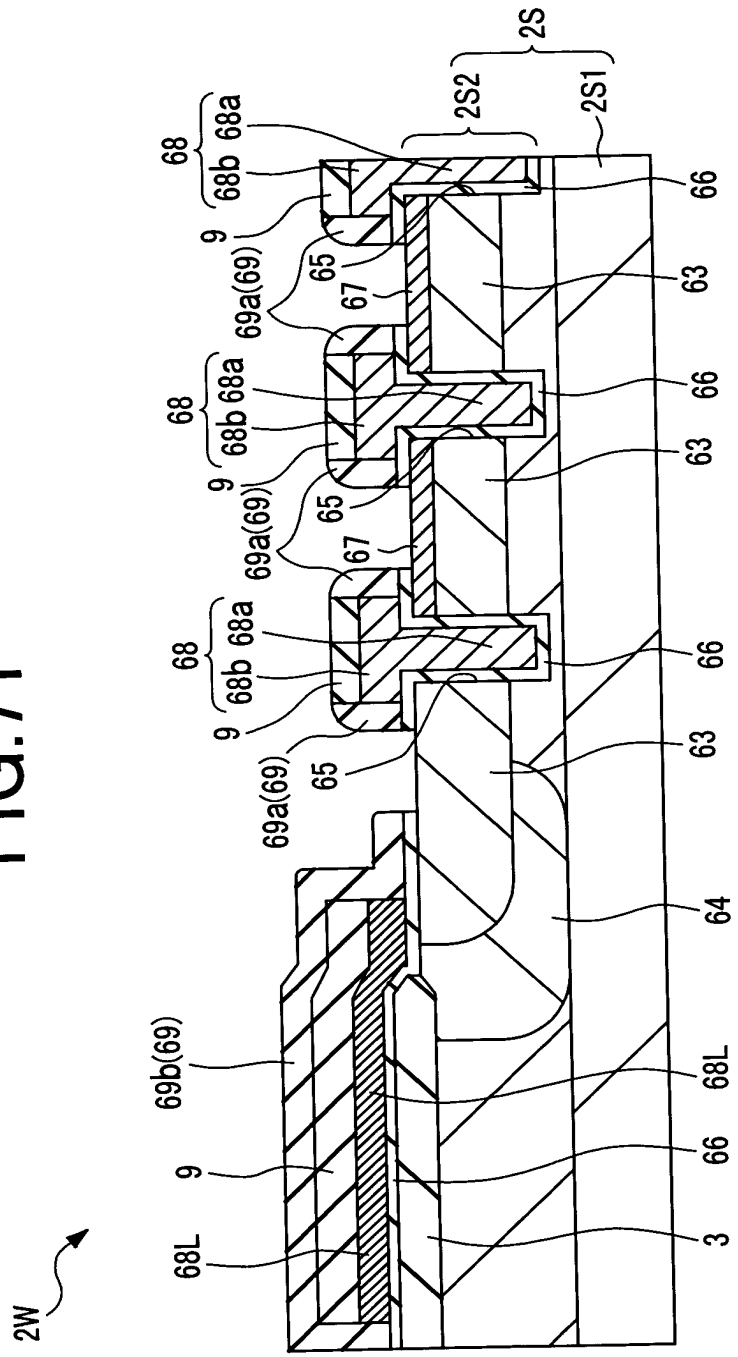

FIG.72

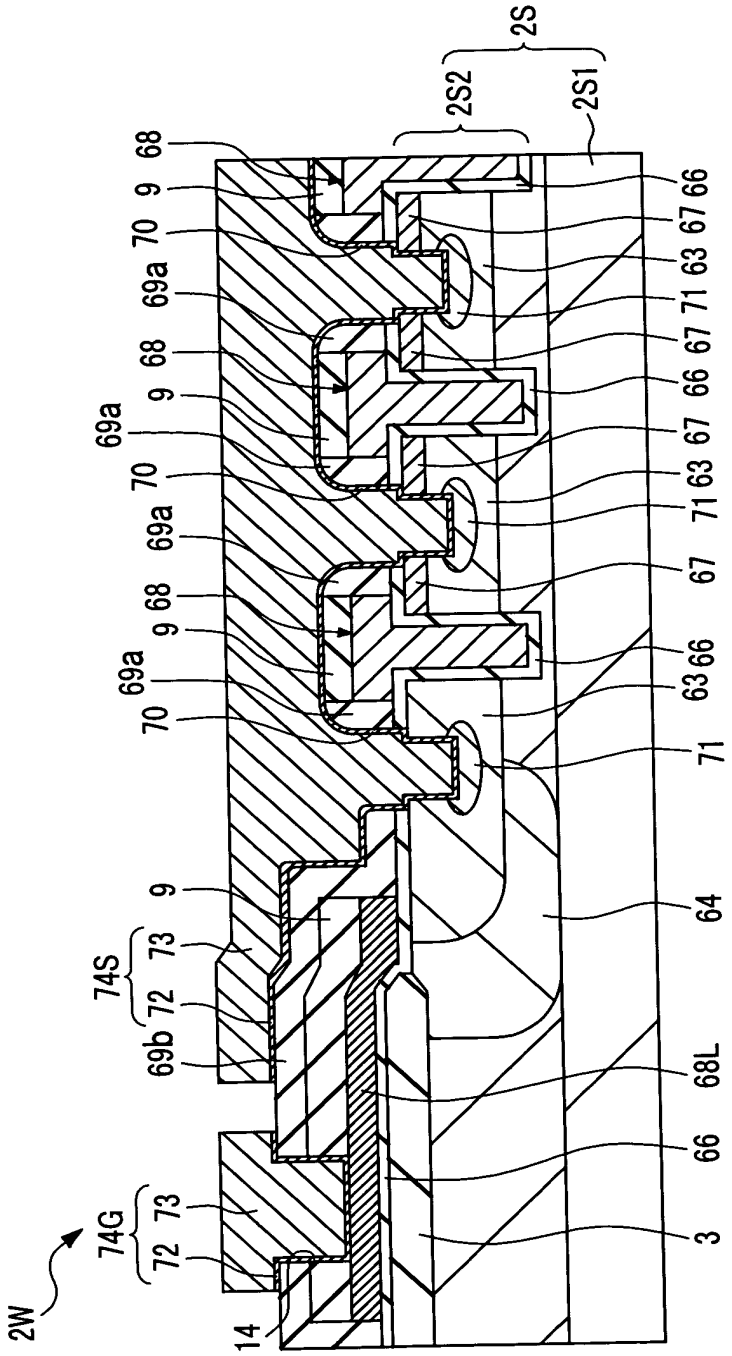
2S
2S2
2S1
68
9
70
69a
68
9
69a
70
69a
68
9
69a
70
9
74S
73
72
69b
74G
73
72
2W
14
66
67
63
71
67
66
67
63
71
67
63
66
71
64
68L
66
3

FIG.73

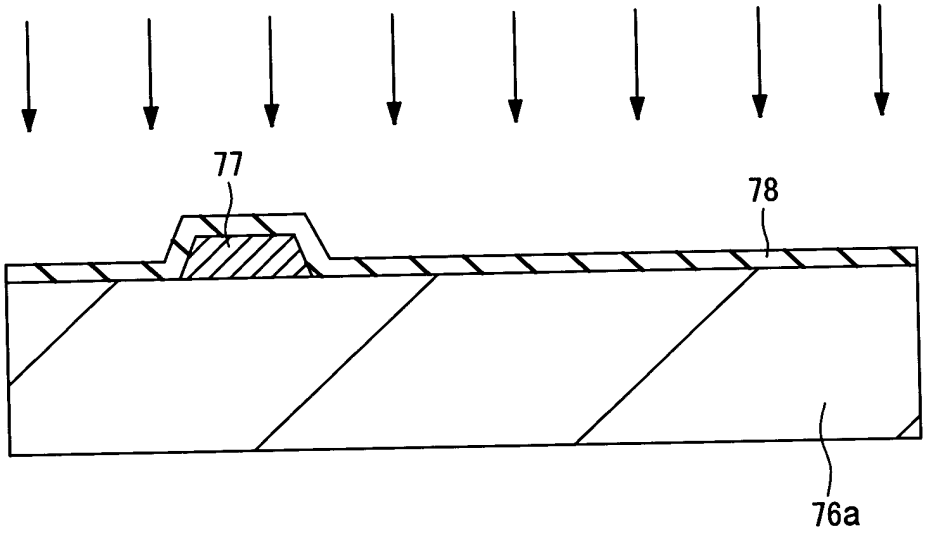

FIG.74

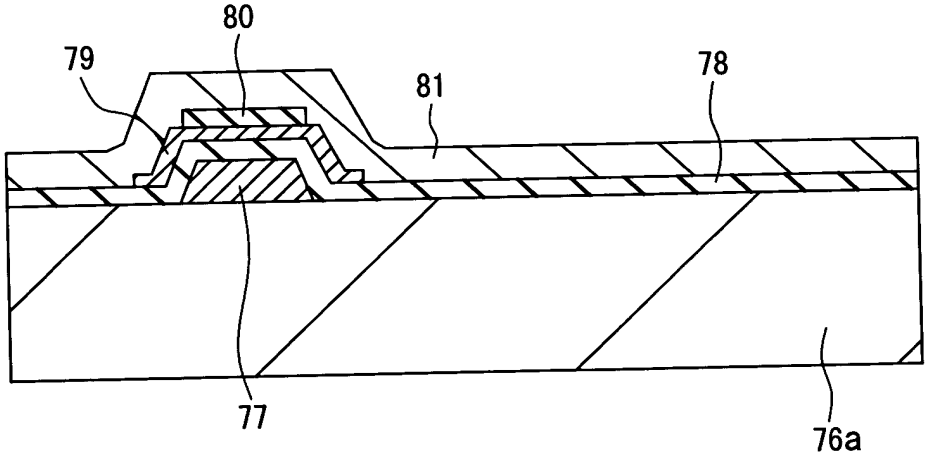

FIG.75

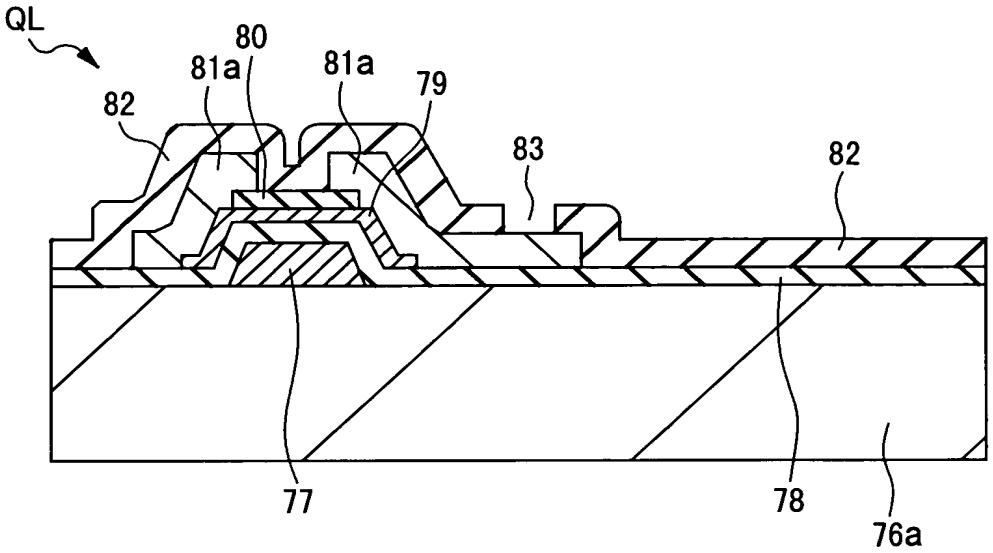
QL
80
81a
81a
79
82
83
82
77
78
76a

FIG.76

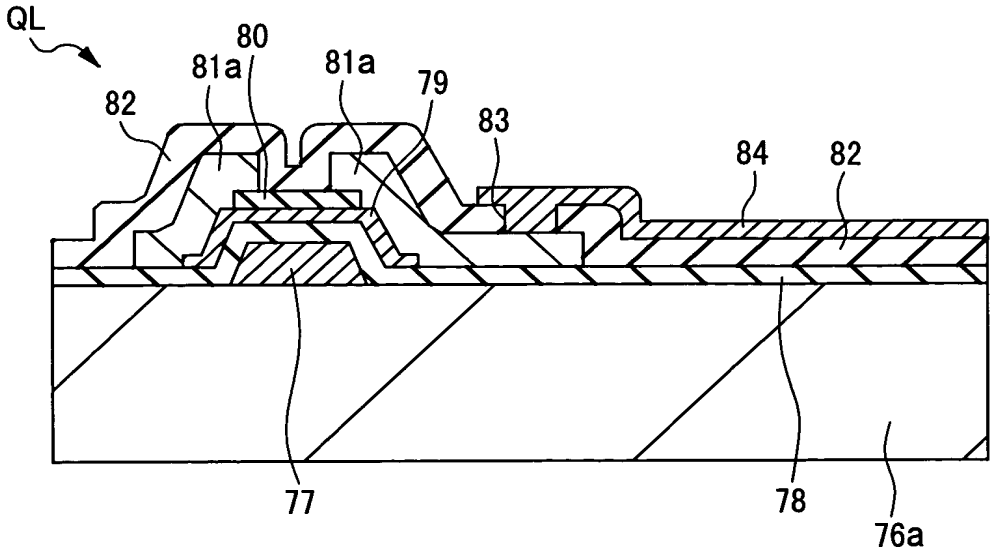
QL
80
81a
81a
79
82
83
84
82
77
78
76a

FIG.77

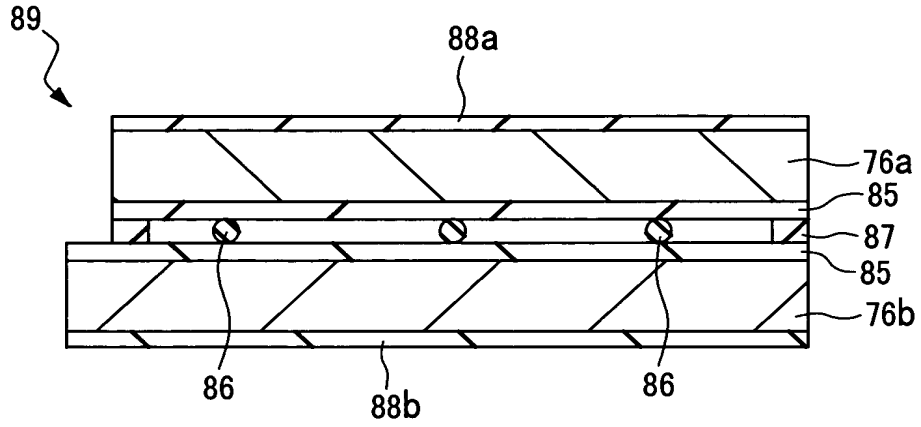

FIG.78